Forest Pest gement in the People's Republic of China

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United States Department of Agriculture
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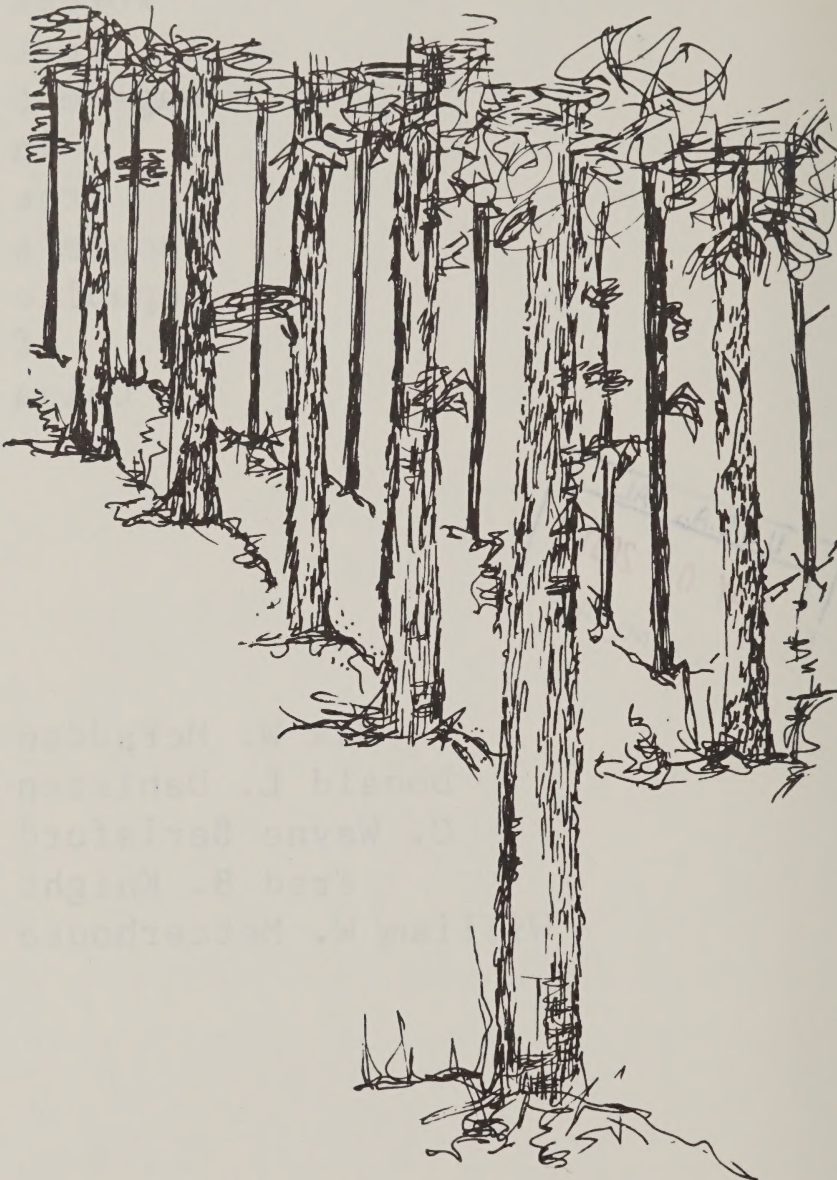

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FOREWORD

On April 23, 1981, a six-person team departed from the United States for the People's Republic of China (PRC). Expected accomplishments for the 28-day trip included:

A review of integrated forest pest management practices in the PRC.

Familiarity with major tree species in selected areas of the PRC and major insect and disease organisms affecting them.

Appreciation of forest protection research and its role in forest management.

Better understanding of the education and training of pest management scientists and practitioners and consideration of opportunities for exchange of scientists and students.

Consideration of opportunities for cooperative studies in integrated forest pest management research, including exchange of biological materials.

The team consisted of Max W. McFadden, U. S. Department of Agriculture (USDA) Forest Service, team leader; Fred B. Knight, University of Maine; Donald L. Dahlsten, University of California at Berkeley; C. Wayne Berisford, University of Georgia; William W. Metterhouse, New Jersey Department of Agriculture; and K. C. Lu, USDA Forest Service (retired).

Funding for the trip was provided through the USDA Office of International Cooperation and Development, with travel arrangements made by the Society of American Foresters.

During the visit the team traveled to Beijing and five provinces from Jilin in northeast China to Guangdong in the extreme south. Twenty-one locations were visited including Ministry of Forestry research laboratories, provincial

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forestry research institutes, county tree farms, production brigade tree farms, a forestry college, and a microbiological factory (<u>see itinerary in appendix</u>).

Our delegation was the first forest protection team to visit the PRC from the United States and, in many instances, we were the first American delegation to visit a specific location, such as a tree farm. Without exception, we were treated with warm hospitality in a friendly, open, cooperative spirit.

This report is a compilation of first-hand observations of pest management in the PRC and of knowledge learned through discussions with Chinese colleagues. A brief account was published by the <u>Journal of Forestry</u> in 1981.

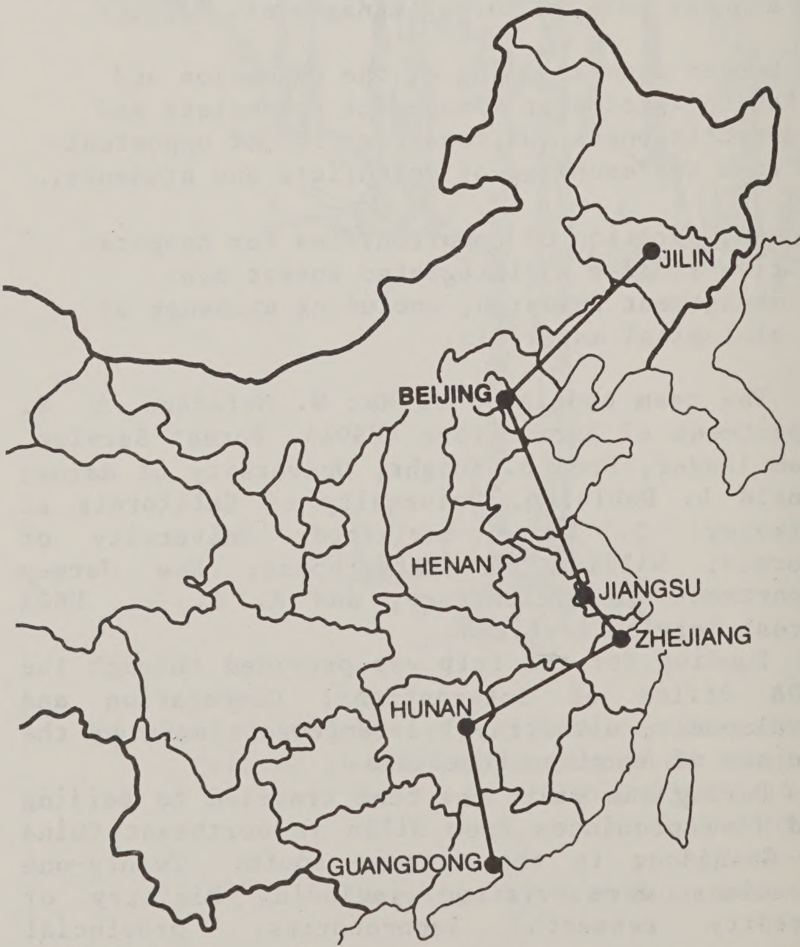

Figure 1. Route Followed by the American Team

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CONTENTS

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TABLES
AND
FIGURES

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OVERVIEW

For many years, China was the least-forested land of any country in the world. In 1949, when the People's Republic of China was established, only 8.6 percent of the total land area was in forest. At that time, the government encouraged a nationwide effort to plant trees. At first, there were no guidelines for planting, and some arable land was lost through afforestation. Now, however, afforestation is limited to those areas considered unfit for crop production. As of 1981, 122 million hectares had been planted. The primary areas for planting are in central China, and plantations there account for 25 percent of the total forested area in the country. The main tree species planted are <u>Pinus</u> spp., <u>Cunninghamia lanceolata</u>, <u>Populus</u> spp., <u>Robinia pseudoacacia</u>, <u>Ulmus pumila</u>, <u>Paulownia</u> spp., <u>Phyllostachys</u> spp., <u>Camellia oleifera</u>, <u>Aleurites fordii</u>, <u>Juglans</u>

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regia, and Castanea fordii. All together, about 100 species have been used in plantations.

The steady growth of these large plantations has also caused an increase in protection problems. Until 1980 there were no laws against indiscriminate cutting, and people collecting firewood caused considerable damage to the forests. In 1980, the Central Committee passed legislation to regulate forestry and to prevent damage or serious losses from all causes. These new regulations have greatly assisted protection work.

Forest insect and disease control is the main thrust in forest protection. Fire is also important but not an overriding concern.

Records indicate that China is one of the first countries to use biological control but only in the last 10 years has this technique been applied to forest insects and disease over vast areas. Beauveria bassiana, Trichogramma spp., and Bacillus thuringiensis (B.t.) are the agents most commonly used, and approximately 600,000 hectares are treated annually. About 50 percent of all infested areas are treated with chemicals each year (greater than 1 million hectares) but China hopes to develop biological control on a larger scale and limit chemical control to essential needs.

Chemical control, reserved for seriously damaged sites, utilizes malathion, Sumithion, Dylox, and DDVP. Two techniques for application are: high volume (at 200 liters per hectare) and ultra-low volume. Backsprayers and aircraft are used to apply both. In high-crown density stands, smoking is sometimes employed.

Owing to the vastness of the size of China, diversity of the flora, and climatic differences, the insect and disease problems are also diverse. We were informed that approximately 2,500 species of insects and about 1,000 species of disease organisms causing tree damage are presently known. Of these, about 100 are considered serious pests. Lists of major insects and diseases are provided in the appendix. Pine moths, Dendrolimus spp., are considered the most serious pests. Each year 2 million

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hectares are damaged by these insects, mostly Pinus and Larix spp. Pine moth larvae are capable of completely defoliating a tree, and 2 years of successive defoliation will cause mortality.

Control of insect pests in the 1950s was by handpicking; in the 1960s, chemical control; and in the 1970s, integrated control using a combination of chemical and biological control techniques. China is currently implementing integrated pest management concepts in many parts of the country and emphasis is on expansion of this effort.

Work on Beauveria bassiana was initiated in the 1950s and its use on a broad scale became more common in the 1960s. Part of the reason for broad acceptance and use of the fungus was a technique that made artificial production easy for the farmers. Simply stated, it is a solid fermentation process that makes use of agricultural byproducts, such as wheat bran and rice hulls. One gram normally provides 10 billion spores. The net result is that Beauveria can be produced and applied by the farmers at a low cost. Each county where Beauveria is effective now has one or two factories for production of the fungus.

Two problems are associated with Beauveria. It causes headaches and nausea in people (especially in the factories) and its efficacy is poor when applications are made under less than ideal climatic conditions. The first problem could probably be solved by developing a means to seal the equipment in the production process, and the second problem, through more attention to timing of application. Research is continuing on these problems.

Another biological control agent is the parasitoid Trichogramma. Eggs from the oak silk moth (Antheraea pernyi) are still considered the best method for mass rearing. Attempts with eggs of other hosts, such as Corcyra cephalonica from rice, have been without success. Apparently, such attempts have resulted in a loss of vigor in Trichogramma. Some interest has been expressed in developing a technique to use artificial eggs.

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B.t. was introduced from the Soviet Union in the 1950s. The Chinese learned the methods of production and built many factories throughout the country. Most of these are closed now because of erratic results. At one, still in operation in Henan Province, annual production of B.t. is 500-600 metric tons. A deep-layer liquid fermentation process yields a water soluble product. When used properly, efficacy of B.t. can attain 80-90 percent. The Chinese consider the erratic results to be related to product quality -- not application. Also, they consider B.t. to have two advantages -- it can be manufactured in large quantities and in many formulations. The task confronting them is to improve quality and to increase production rate. Cost, however, will probably continue to limit widespread use.

The Chinese have succeeded in isolating different kinds of virus from various species of insects. The efficacy of these viruses, which include granulosis, cytoplasmic polyhedrosis virus, and nucleopolyhedrosis virus, is good but there is no artificial media to increase production. Extensive use of virus is limited by effects on the environment and human health.

Other natural control agents are the parasite, Scleroderma sp., used on Saperda populnea; lady beetles, Chrysopa; and anthocorids used on Matsucoccus. Three species of insectivorous birds have also been used in China. In Shandong Province, for instance, one pair of Cyanopica cyana interposita with their young can protect one mu (a unit of land measurement equivalent to 0.1657 acre).

There is an understanding that a combination of methods is needed in solving any pest problem. Each method, by itself, has a weakness. Integrated pest management (IPM) can overcome these deficiencies but according to Li Yu-ming of the Ministry of Forestry, IPM theory and practice are just being initiated in China.

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FOREST
PROTECTION
RESEARCH

The Ministry of Forestry, which derives its authority from the State Council, is responsible for all aspects of forestry in the People's Republic of China. Its tasks include providing professional guidance to both state and collective-owned forests, plans for afforestation, reforestation, and harvest, annual information for decisionmaking at the national level, short and long-term planning, direction for the many institutes and universities of teaching and research, and needed harvest equipment and other machinery for forest units.

The Ministry of Forestry includes more than 20 bureaus, among which are the Forest Protection Bureau and the Academy of Forestry Sciences.

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Forest Protection Bureau

The Forest Protection Bureau has four divisions and plans for a fifth. The divisions are:

1. Fire Control
2. Forest Insect and Disease Control. This administrative unit is responsible for reporting trends in pest problems, collecting basic information on important forest pest species, and transmitting this information nationwide. Other responsibilities include providing guidelines for development of research plans and reviewing plans submitted in response to guidelines; performing extension work to communicate knowledge to all parts of the country through propaganda or by regulations; developing financial plans for rural areas in cooperation with the Ministry of Finance; inspecting nursery stock and seedlings for disease and insect pests; establishing quarantines to prevent the spread of disease and pest organisms.
3. Natural Protection. This unit includes wildlife.
4. Forest Policy and Administration. This division was established to control damage to forested areas by humans.
5. Forest Policy Regulation (proposed). A fifth and new division with policy enforcement responsibilities may soon be added.

Academy of Forestry Sciences

The Chinese Academy of Forestry Sciences is organized much the same as a bureau within the Ministry of Forestry but appears to have greater prestige than other units such as the Forest Protection Bureau. The Academy is composed of seven research institutes:

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Beijing
Forestry Research Institute
Wood Products Research Institute
Forest Information Research Institute

Zhejiang Province
Subtropical Forest Research Institute

Jiangsu Province
Forest Products Chemical Research Institute

Yunnan Province
Lac Research Institute

Guangdong Province
Tropical Forest Research Institute

Staff totals 1,613 of which 800 are research workers. In addition, there are three experimental bureaus, one in Inner Mongolia, one in Xinjiang, and a third in Xizang.

Forestry Research Institute

From a pest management research point of view, this is the most important institute within the academy. Located in Beijing, it has a staff of 282 with 19 professors, 150 assistant professors, 34 research workers, 9 administrative clerks, and 70 research assistants. The mission of the institute is to carry out nationwide projects on fundamental forestry and to promote basic research and training of postgraduates. Silviculture provides the foundation for all work at the institute including:

Forest genetics and tree improvement
Plantation management
Management of native forests
Forest insect and disease control
Forest ecology

Research departments within forest insect and disease control include:
1) forest management, 2) forest administration,

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3) windbreaks, 4) commercial plantations, 5) economics, 6) forest ecology, 7) forest flora, 8) forest soils, 9) physiology, 10) genetics and breeding, 11) species introduction, 12) forest entomology, 13) forest pathology, and 14) environmental protection.

During our visit to the Forestry Research Institute we were informed that work in entomology and pathology was being emphasized. Deputy Director Cui explained that presentations would be given in areas of taxonomy and identification, insect pathology, natural enemies, and plant pathology.

Department of Entomology

This department has 38 staff members: 2 scientists, 23 assistant researchers, 2 trainees, 5 technicians, and 6 laborers. Research groups study:

1. *Bacillus thuringiensis* (*B.t.*)
2. Insect virus
3. Natural enemies
4. Chemical insecticides
5. Insect ecology
6. Identification and classification
7. Vertebrate zoology
8. Biological control of *Matsucoccus matsumurae*
9. Biological control of *Anoplophora glabripennis*.

The overall objective of the department in 1981 was to concentrate on insect pests of *Populus* and *Pinus* species.

Department of Insect Pathology

This group, which has seven staff members at present, has worked since 1960 on use of fungi, bacteria, and virus for control of insect pests. A local strain of *B.t.* was developed but cost was too high for widescale use. The unit has also worked on development of *Beauveria bassiana*, a fungus widely used in China, especially in the

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south. Since 1978, the unit has concentrated on virus research.

Department of Biological Control (Natural Enemies)

This unit is emphasizing biocontrol with mantids, a pentatomid, and a parasitic wasp (*Scleroderma* sp.) on *Semanotus bifasciatus*, a long-horned beetle, and *Saperda populnea*, the small poplar borer.

The wasp can provide up to 80 percent control on *Saperda*. The pentatomid, *Arma chinensis* Fall., is widely distributed and feeds on pine caterpillar and a poplar caterpillar, *Clostera anachoreta*. Six species of Mantidae are being intensively studied. They are known to prey on 40 different species of pests and have a large feeding capacity. They are used on pine caterpillars, pine aphids, and tussock moth on willow. Populations of *Dendrolimus tabulaeformis* have been reduced by as much as 30 percent by mantids.

Department of Forest Disease

The forest disease unit, originally a section within the Department of Forest Protection, was established as a department in 1962 and now has 11 professionals. Over the past 50 years, emphasis has been on survey of virgin forests for pathogenic organisms. In the 1950s, research concentrated on control for damping-off of seedlings and, in the 1960s, on diseases of *Populus* spp., larch leafcast, and dieback. Some of the more troublesome problems in China are: blister rust of pines (*Cronartium ribicola*) in the north, northeast, and southwest parts; chestnut blight (*Endothia parasitica*); Dutch elm disease; witches' broom of *Paulownia fortunei*; root rot of pines (*Armillariella mellea*); damping off (*Fusarium* spp.); *Glomerella cingulata* of *Abies*; *Lophodermium pinastri* of *Pinus massoniana*; *Leptosphaeria* sp. of *Phyllostachys* spp.; *Balansia take* of *Phyllostachys* spp.; *Pythium* and *Rhizoctonia*.

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Education and Training

The education and training of forest protection personnel are part of the overall forestry education program of the PRC. The educational hierarchy resembles that found in many Western countries. Students are trained as professional foresters and as technicians, and many short courses are provided for forest workers. Postgraduate studies are available in the large forestry colleges.

The Ministry of Forestry has responsibility for leadership and direction of education, but not all programs are controlled by the agency. The nation has eleven forestry colleges; six of these are directly operated by the ministry while five others are provincial institutions. In addition, departments of forestry are associated with many agricultural colleges. Secondary schools train technicians. In 1981, about 14,000 students were enrolled in the eleven forestry colleges and 11,000 students in the technical schools.

Each year about 3,000 students enter the forestry colleges and about the same number graduate at the end of the 4 year curriculum. Students come from all over China to attend the three largest institutions at Beijing, Harbin, and Nanjing. The remaining eight have a more regional student body. Entrance is by examination. Professors are selected by the ministry after a careful but rigorous screening for professional knowledge and experience.

Forest protection is one of the common majors. At Nanjing Technological College of Forest Products, the important majors are silviculture, forest protection, and landscape architecture. Sixty students are enrolled each year in forest protection. Four other colleges have a sequence (major) in forest protection: Beijing, Harbin, Kunming, and Hangzhou. The last two of these are provincial institutions. Each year the five institutions produce about 180 forest

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protection specialists. Demand for graduates is strong, for shortages of trained manpower are still evident as the nation continues to recover from the effects of the cultural revolution.

Extension and Technology Transfer

A formal extension program of the type found in the United States was not readily apparent, though a well-developed system of technology transfer was obvious. Technology transfer seemed to be everyone's duty. The transfer of information from the ministry and national institute to provincial research institutes and to county programs and collective farms seemed to be working effectively.

We saw evidence that written materials prepared in the research institutes were being utilized in the field. We were impressed with the close cooperation between the technical people in the province and the workers at such locations as Miyun County, the Liaoyaun City Forest Insect and Disease Control Station, the Chang-Le Tree Farm in Yahan County, the Shashi Commune in Linyang County, the Huicheng-Zhen City Forest Farm, and Baiyun Shan Forest Farm.

We do not suggest that all new methodology is accepted by workers in the field. On the contrary, we saw many examples of poor practices that had not been corrected. However, the process of continuing education was evident and is achieving results. Sophistication of technology transfer varies considerably from province to province and may vary between production units within provinces. Actual results may depend on leadership within the units and the resources available to them.

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FOREST INSECTS AND DISEASES

Defoliators

Defoliators are the most important group of forest insect pests in the PRC (Table 1). In every location visited, a complex of defoliators was the main focus of the forester's and pest manager's concerns. As a result, research and control strategies are dominated by these insects.

Since plantations are the largest component of China's forests, they are the focus for most defoliator research. Considerable effort has been made to plant trees in the cities and, therefore, defoliator research has also been extended to urban situations. Remaining natural forest is generally inaccessible to the populace, and natural stands do not appear to suffer extensive damage from defoliators. We were informed of this on several occasions. The inference is that protection is due to the diverse nature of natural stands. However, we did not see any data, results, or scientific studies to corroborate this viewpoint.

At the Forestry Research Institute in Beijing, studies on defoliators aim at development of techniques for monitoring and forecasting numerical change in pine moth populations. This is the only place we visited where population dynamics studies were in progress. Li Tian-sheng, as Assistant Research Fellow in the Department of Forest Entomology, expressed great interest in the development of population models, use of computers, and modeling approaches being used in the United States.

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Studies were in progress on pine moth biotypes; development of virus for a poplar caterpillar, Clostera anachoreta, and an introduced pest, the fall webworm, (Hyphantria cunia); classification of sawflies (although not considered to be too important); and use of mantid species as potential biological control agents.

Insect pests of poplar and pine are considered of primary importance in China by the scientists at the Forestry Research Institute and they consider Dendrolimus punctatus, a defoliator, to be the worst forest pest (Table 1).

In Jilin Province, in northeast China, the most important defoliator is D. superans Butler (=D. sibericus), which feeds on several species of pine, larch, fir, and spruce. The most important species in central and southern China is D. punctatus, but it is not a problem in the northeastern provinces. Another species, D. spectabilis, attacks pines but is more important south of Jilin Province. The larch caterpillar, D. laricus, does not occur in China. Dendrolimus species were mentioned at every location we visited.

Larch (Larix olgensis) is commonly planted in Jilin Province and its only important pest is the larch casebearer, Coleophora laricella. The team observed extensive casebearer damage throughout the areas visited in Jilin. Another defoliator of note in Jilin Province is the elm leaf beetle, Ambrostoma quadriimpressum Mots. on Ulmus pumila. The oriental moth Cnidocampa flavescens (Waller) a saddleback, family Eucleidae, and the Chinese gypsy moth, Lymantria dispar japponica, occur on many hardwoods, but are only occasional pests in this province.

Defoliators other than Dendrolimus of concern in Jiangsu Province were Parocneria terebranthi, a serious pest on Thuja orientalis; Clania variegata, a bagworm; Algedonia coclesalis on bamboo; Melalopha anachoreta on Populus; and Parocneria furva.

In Zhejiang Province we were told that the warm climate and high rainfall (1,400 mm per year) were responsible for many forest insect and disease problems. About 600 species of insect

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pests have been recorded and many of these are defoliators belonging to the families Eucleidae (saddlebacks), Psychidae (bagworm), Sphingidae, Saturniidae, Geometridae, and various butterflies. A pest of bamboo, Algedonia coclesalis, was of some concern as was Ochrostigma albibasis, a notodontid on oak, and Buzura suppressaria, a geometrid pest of oil-bearing sycamore (tung oil tree or Aleurites fordii).

As we traveled south, there was more and more concern for insect and disease pests of bamboo. At the Subtropical Forest Research Institute in Zhejiang Province, where various bamboo pests are studied, we were told that bamboo was attacked by 250 species of insects and a variety of birds. Algedonia coclesalis, Apamea repetia, and several noctuids and other leaf-eaters cause problems in seven provinces and municipalities on the middle and lower reaches of the Yangtze River.

To the west, in Hunan Province, the primary concern was Dendrolimus punctatus on Pinus massoniana. Other defoliators were a moth, Lebeda nobilis, a defoliator on camellia; two geometrids, Buzura suppressaria and Biston marginata; Euproctis pseudocospera; Dasychira sp.; and a grasshopper, Ceracris kiangsu.

In Guangdong, the southernmost province, the major concern once again was Dendrolimus punctatus. Another defoliator mentioned was Bineta (Besoia) goddrica on bamboo. It was pointed out that no leaffeeding Chrysomelidae had been found on Eucalyptus maculata growing there.

At the Xin-Hui County Forest Farm in Guangdong Province, we were told that a system had been developed for predicting pine moth outbreak. This sophisticated monitoring system consists of permanent plots and mobile observation points. Twenty sample trees at each monitoring site are utilized, and weather data and insect biological information is collected by foresters and special monitors. All data are recorded on a form (Figure 2) for later analysis. Other defoliators of Pinus massoniana on this forest farm were Dendrolimus kikuchii, D. kikuchii ochraceus, and Dasychira sp.

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Table 1. Major Forest Defoliators

Name (Order)	Host	Range
Dendrolimus punctatus (Lepidoptera)	Pinus massoniana P. elliottii	Southern provinces
Dendrolimus spectabilis (Lepidoptera)	P. thunbergii (=tabulaeformis)	Liaoning and adjacent provinces
Dendrolimus sibericus (=superans) (Lepidoptera)	Larix sp. P. koraiensis P. silvestris P. thunbergii Abies holophylla A. nephralepsis Picea jezoensis	Northeastern provinces, Hebai, Inner Mongolia,
Pyrrhalta aenescens (Coleoptera)	Ulmus pumila	Hebai, Henan, Shanxi, Shandong and Inner Mongolia
Ambrostoma quadriimpressum (Coleoptera)	Ulmus pumila	Northeastern area and Inner Mongolia (eastern)
Apocheima cinerarius (Lepidoptera)	Populus sp.	Henan, Hebai, Shanxi, Inner Mongolia, and Xinjiang

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In The People's Republic of China

Name (Order)	Host	Range
Stilpnotia salicis (Lepidoptera)	Populus sp. Salix matsudana	Northeastern area
Ocneria dispar (=Lymantria dispar japponica) (Lepidoptera)	Xylosma congestum Salix sp. Beticla japonica Larix sp. Malus Pyrus	Northeastern area
Ceracris kiangsu (Orthoptera)	Phyllostachys sp.	Jiangxi, Fujian Hunan and Sichuan
Algedonia coclesalis (Lepidoptera)	Phyllostachys sp.	Zhejiang, Hunan, Jiangxi and Sichuan
Coleophora laricella (Lepidoptera)	Larix olgensis	Northeastern provinces
Lymantria xylina (Lepidoptera)	Casuarina sp. Robinia pseudoacacea Pterocarya stenoptera	Fujian, Guangdong, Guanxi
Euproctis pseudoconspersa (Lepidoptera)	Camellia fordii	Southern and Central provinces below Yangtze River

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Figure 2. Pine Moth Survey Form
Xin-hui County, Guangdong Province.

Commune	Brigade	Name of Hill	Slope Facing	Top Middle Bottom

Tree Age	Avg. Height	Crown Cover	Area Covered	Percent Infestation	Mu

Name________________________ Date______________

No. Tree	No. Larvae	Life Stage	Number Egg Masses	No. Pupae	Remarks
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

Bark Beetles

Bark beetles are not considered to be a major pest in China, but in the northern provinces workers were concerned about their damage and expressed interest in control techniques used in the U.S.

In Jilin Province we saw thinning operations in pole-sized stands of *Larix*, mostly *L. olgensis* and *L. sibericus*. Trees which had not been

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removed from the stands and those which had been decked for processing were heavily infested by Ips subelongatus. The size and gallery pattern of this species is similar to that of I. calligraphus in North America. Trees are killed in small scattered spots, especially where some stand disturbance has occurred. Although I. subelongatus is regarded as a serious pest, we were unable to obtain volume or percentage estimates of annual tree mortality.

We also saw examples of damage to pines by I. typographus and I. duplicatus, but did not receive additional information. Controls for I. subelongatus include peeling before use; many boles are peeled before beetle broods can emerge. Scolytus spp. bark beetles were mentioned as pests of elms and birches but no species names, damage estimates, or life histories were provided.

Several species of pine and larch are attacked by Blastophagus piniperda L. This beetle normally oviposits and rears brood in boles of weakened or recently felled trees. In this capacity it is a minor pest. In stands severely weakened by defoliators or scale insects, however, adults of B. piniperda also bore into and kill shoots, thereby causing deformities and growth loss. In Jilin Province this habit makes it an important insect pest of Scotch pine. We saw numerous attacks on decked logs removed from stands of Scotch pine, P. sylvestris, in thinnings. Control consists of peeling logs, spraying to prevent attacks, and use of "trap logs" which are allowed to become infested and are then peeled and the bark burned prior to emergence of brood.

We saw specimens of Dendroctonus armandi in collections at several locations. This large beetle attacks the lower bole and roots of pines, especially P. armandi, in northwestern China. We did not see any evidence of this species in the field and none of the workers with whom we talked considered it to be a problem. We were not provided with information on either its biology or control.

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Insects which attack and bore into the trunks of trees are very important in the PRC, especially in trees planted as ornamentals and windbreaks. Longhorned borers (Coleoptera: Cerambycidae) are the main concern of foresters and entomologists. The life cycles of the important species are similar in that adult beetles lay eggs on or in the bole or limbs of the tree and larvae tunnel in the wood as they complete their development.

Since Populus spp. are frequently used for street plantings and windbreaks, borers constitute a major problem in urban forestry. All Populus spp. currently being used are attacked by borers, particularly cerambycids in the genus Saperda. In the areas around Beijing and in Jilin Province, damage by S. populnea was severe. Most trees which were 8" DBH or larger had evidence of heavy attack. Mortality usually occurs when heavily infested trees break off in high winds.

Monochamus alternatus, another cerambycid, is a pest of Pinus spp. It can cause serious damage when trees have been weakened from defoliation by Dendrolimus caterpillars or by heavy infestations of the pine bast scale, Matsucoccus matsumurae. It may also attack spruce and China fir, Cunninghamia lanceolata. The latter is frequently also attacked by Semanotus bifasciatus. Larvae of this cerambycid tunnel in the bole and large branches and apparently can damage stands when populations build up in weakened trees.

Other common borers are Apriona germari on walnuts, tung, poplars, and willows; Batocera horsfieldi on chestnut, tung, tallow tree, mulberry, and poplar; Anoplophora glabripennis on chinaberry, elm, poplar, and mulberry; and Chelidonium gibbicolle on walnuts.

During visits to various laboratories, we often saw specimens of several species of Cerambycidae, Burprestidae, and Sessidae that were said to attack trees but we were not given information on hosts or damage.

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Seed and Cone Insects

Seed production is reduced by insects feeding on seeds or cones or by destruction of shoots which would subsequently bear the fruiting structures. Because PRC scientists are in the early stages of seed orchard establishment, seed and cone insects are receiving major attention at this time. However, there are several species which could seriously affect future production in seed orchards, including those established with pine species introduced from the U.S.

Specific damage to cones by insects was mentioned by PRC workers at only one location -- the Jong Yu-tan Forestry Tree Farm near Changchun in Jilin Province. There, the coneworm, *Dioryctria abietella* (Lepidoptera: Pyralidae), had killed up to 20 percent of the cones in *Pinus koraiensis* stands. Normal mortality from coneworms is about 10 percent. We found *D. abietella* and *D. splendidella* commonly represented in collections and in lists of pests provided by PRC scientists.

Dioryctria splendidella is common in the southern provinces of the PRC where it frequently attacks the terminal shoots of young pines, including slash and loblolly pine introduced from the U.S. It is potentially a very bad pest in seed orchards or seed production areas because it attacks both shoots and cones on large trees.

Other shoot borers that may be important in future seed production are *Eucosma* spp.; *Rhyacionia* spp., particularly *R. pinicolana* on massonian pine; *Petrova* spp., particularly *P. cristata* which attacks both pine cones and shoots; and *P. salweenensis*, which we collected and reared from shoots of *Pinus caribea* during a visit to the arboretum at the Hunan Provincial Forest Research Institute.

The bark beetle, *Blastophagus piniperda*, bores into twigs and feeds in the pith. Cone production in pines could be reduced by death of

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potential conebearing shoots and break-off of damaged shoots bearing large second-year cones.

We were unable to determine if controls had been developed for any of these problems in seed orchards. It was evident that planning for orchard establishment has not included insect control and no studies on potential seed pests have been initiated.

The insects mentioned, and others we may be unaware of, may have the combined capability to prevent realization of potential seed production from many of the newly established orchards. We feel that research on their biologies should be undertaken immediately in order to develop a future pest management program in seed orchards. Otherwise, there will be heavy reliance on chemical insecticides to maintain acceptable seed production.

Regeneration
Insects

Insects which attack seedings and saplings are numerous in the PRC, but much of the damage does not cause tree mortality. Many which were discussed above as seed and cone insects (shoot borers) also infest regeneration. We saw considerable evidence of shoot attacks on the major planted pine species and on _Cunninghamia_ by the China fir shoot moth, _Polychrosis cunninghamiacola_ (Lepidoptera: Tortricidae). China fir appears to tolerate attacks by the moth rather well and, on healthy trees, damage apparently is confined to some minor growth loss. Attacks on the terminal shoots of very small trees, however, may cause poor form or multiple stems.

Other insects of pine regeneration include the aforementioned species of _Eucosma_, _Petrova_, _Rhyacionia_, and _Dioryctria splendidella_.

Defoliation by _Dendrolimus_ caterpillars occasionally occurs in regeneration, but usually is not complete except in isolated attacks near heavy infestations in older stands. In Hunan

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Province, we saw evidence of <u>Dendrolimus</u> feeding and a few scattered caterpillars and cocoons in slash pine plantations, but damage was generally light and only an occasional tree had significant defoliation.

Nursery Insects

Insects which attack seedlings in nurseries and outplantings in the PRC may become serious at times. Larvae of <u>Oligia</u> <u>vulgaris</u> attack new shoots of bamboo, <u>Phyllostachys</u> spp., and prevent or deform growth. They also attack the stems of several native grasses.

Seedlings of hardwoods and pines are attacked by cutworm larvae (Lepidoptera: Noctuidae) which occasionally become numerous enough to require insecticide treatments. White grubs, especially members of the genera <u>Anomala</u> and <u>Maladera</u> (Coleoptera: Scarabaeidae), may cause serious damage by feeding on roots of seedlings in nurseries. Mole crickets, <u>Gryllotalpa</u> spp., may also occasionally kill seedlings by feeding on the roots.

Pests of Wood in Use

We obtained very little information on pests of wood in use. The subject was not discussed until we reached Hunan Province. At the Hunan Provincial Forestry Research Institute, however, we met Associate Director Peng, who is personally interested in taxonomy of termites. Although we were not provided with facts or figures, it was our impression that termites are a significant factor in China, especially the Formosan termite, <u>Coptotermes</u> <u>formosanus</u>. No mention was made of the magnitude of the problem nor of damage by other insects such as wood-destroying beetles.

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Forest
Diseases

China is combating forest diseases as it is forest insects. For many years now, the main research thrust has been to survey and describe the diseases in natural forests throughout China. As we visited various field units in the provinces, we encountered several efforts to control particular diseases.

Our information on diseases in northeast China, in particular, is sparse and is based on discussions at the Jilin City Forest Research Institute. The most important diseases are needle cast of Larix olgensis caused by Lophodermium pinastri, blister rust of red pine (Pinus densiflora) caused by Cronartium ribicola, and root rot of Populus spp. caused by Armillaria mellea. The poplar root rot causes extensive mortality in young stands, especially on poor sites.

Chestnut blight (Endothia parasitica) occurs on several species of Castanea in China. It is not generally considered to be severe, but even the most resistant species may be susceptible when under stress. The Chinese have found that painting cankers with a 1:400 solution of diethylsulfoxide will destroy better than 90 percent of them.

In central and southern China, disease is more prevalent than in the northern provinces. We learned from Jiang Feng-li that in Zhejiang Province there are more than 100 different kinds of plant diseases, including mildews, rusts, anthracnoses, damping-off diseases, and root cankers. Some of the more important ones are:

Bamboo	Leptosphaeria sp. on Phyllostachys edulis
Larch	damping-off caused by Fusarium, Pythium, and Rhizoctonia Cercospora sequoiae (seedling) Glomerella cingulata Pseudomonas cunninghamia (bacterial rot) yellowing (physiological disease)

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Pines	damping-off caused by *Fusarium*, *Pythium*, and *Rhizoctonia*
	Cercospora pini-densiflorae (leaf spots)

While in Zhejiang Province, we visited the Subtropical Forestry Research Institute where Zhang Shu-Ching provided additional information on three major diseases in the region:

1. Stag-head of *Phyllostachys pubescens*. In the early 1960s, in the coastal region of Zhejiang Province, this species of bamboo was severely attacked by the stag-head disease; over 700,000 hectares were affected. The causal organism is *Leptosphaeria* sp. The institute, under the direction of Zhang, found that pruning the diseased shoots and cutting off dead heads or stems seems to be the most effective control. When chemical fungicide is applied in addition, control may reach 70-90 percent.

2. *Colletotrichum camelliae* of oil tea camellia. This fungus attacks various species of the oil-tea tree, particularly *Camellia oleifera*. All tissues above ground can be affected, leading to defoliation, wilting, and blast. In southern China, it is estimated that annual losses of oil-tea trees by this disease may exceed 20 percent. The institute has studied the infection cycle, occurrence and development of the disease, and biological characteristics of the pathogen. An integrated pest management method has been adopted, using selection and disease-resistant species, types, and individuals of *Camellia*. Damage has been reduced by 70-80 percent. The mechanism of disease resistance will be studied in the near future.

3. *Fusarium* sp. of tung oil tree. This is a vascular disease of tung oil trees caused by *Fusarium* attacking *Aleurites fordii* at the age of 3 to 4 years. Severe damage has been reported in tung-growing areas in the provinces of Guangxi, Zhejiang, Jiangxi, Hunan, and Sichuan, particularly in pure tung forests on low hills with red soils. The institute has studied the disease

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since 1979 and has gained knowledge in identification, biological specialization, host ranges, and epidemiology of the pathogen. Selection of disease-resistant varieties is under way.

At the Hunan Provincial Forestry Research Institute, Deputy Chief He leads work on diseases of *Cunninghamia* and *Camellia*. Research on *Bacillus subtilis* as a control for *Colletotrichum* is also in progress. Other major diseases in Hunan Province are:

Colletotrichum camelliae of Camellia
Fusarium sp. of *Aleurites fordii*
Cercospora aleuritides of *Aleurites fordii*
Glomerella cingulata of *Larix*
Pseudomonas cunninghamiae of *Cunninghamia lanceolata*
Leptosphaeria sp. of *Phyllostachys nigra*

In south China, primarily Guangdong Province, *Pinus massoniana*, the principal tree in afforestation, suffers from *Cercospora pini-densiflorae*, *Diplodia pinea*, and *Lophodermium pinastri*. No work was in progress on any of these organisms at the Gui Feng Agricultural Farm where we visited.

At the Bai Yun Forest Farm, about 7 km from the city of Guangzhou, we learned of two diseases of significance. Damping-off is at times troublesome on both the true pines and *Cunninghamia*. Causal organisms are *Pythium debaryanum*, *Rhizoctonia solani*, and *Fusarium solani*. The second disease is severe dieback of *Pinus massoniana* planted on some of the steep slopes. The causal organism, *Diplodea pinea*, may cause dieback, defoliation, and malfunctions in stems or branches. Damage is most severe on trees injured by hail, or which have suffered moisture stress, especially on marginal sites. The disease occurs twice a year: from March to May, and from July to August. Under natural conditions, it appears only after the rapid shoot elongation ceases. A competitive relationship exists between the pathogen and a saprophytic species of *Pestalotia*. The latter may prove useful for biological control of the disease.

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PEST MANAGEMENT

Parasites and Predators

Of the parasites and predators, Trichogramma spp. are the most commonly used, although there is some research on and local use of other natural enemies, including birds. Throughout our trip we were told of the efficacy of Trichogramma spp. in controlling forest pests but because of language barriers and the lack of published material we were not able to evaluate these programs.

All pest control in China is operated by local units, be they provincial organizations, communes, tree farms, production teams, or municipalities. This cottage industry appears to be ideal for application of biological controls and may be the reason for the apparent success of

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these programs. Production and release strategies and techniques with Trichogramma spp. appeared to be very similar in each area visited with only some slight variation from one unit to the next. An exception to this is the evaluation technique used to determine efficacy.

Details on the production of Trichogramma at several units are discussed below, but the technique of using eggs from the oak silk moth (Antheraea pernyi) is still considered best for mass rearing. Attempts have been made to use eggs of other hosts, such as Corcyra cephalonica from rice, but without success. Apparently, such attempts have resulted in a loss of vigor in Trichogramma. As long as oak is common and the oak silk moth is easy to rear and the cocoons still usable for silk production (although lower in quality), there is little incentive to change, although there is interest in developing a technique to use artificial eggs.

The Miyun County Agricultural Station, about 80 kilometers northeast of Beijing, is one of many stations for mass production of Trichogramma; in this case, T. dendrolimi and T. ostrinia, both of which are used against the corn borer. This particular laboratory has been visited by at least four delegations and the rearing process has been fully documented elsewhere. The station is capable of producing 100 million Trichogramma per year. They are usually released at a rate of 200,000 per hectare and are said to be 70-80 percent effective on corn and sorghum, and sometimes on sunflower.

Production of Trichogramma is based on eggs of the oak silkworm, Antheraea pernyi. The moths are reared on fieldplanted oak trees that are pruned for maximum foliage growth. We suspected that they must be subject to natural fluctuations in population density but were told that if cocoons are difficult to obtain from one source they will request them from another source where production is normal.

The main focus at the Jilin Provincial Forest Research Institute was on T. dendrolimi for control of the pine moth, Dendrolimus superans. This parasite is also being used on three

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hardwood defoliators: Cnidocampa flavescens, the oriental moth; Cerura spp.; and Clostera spp.

Some work was being done on another egg parasite, Anastatus bifasciatus Fon. (family Eupelmidae); in a more limited way, on a scelionid egg parasite, Telenomus sp.; and on Arma custus (family Pentatomidae), a hemipteran predator of the larvae.

Laboratory studies with T. dendrolimi at this institute have shown that each female lays a mean of 112.6 eggs (213 maximum), and can attack from two to nine ($\bar{x}$ = 5.7) Dendrolimus eggs. A maximum of 80 Trichogramma can be produced from a single Dendrolimus egg (no mean value was given). With the oak silk moth, Antheraea pernyi, a maximum of 175 Trichogramma ($\bar{x}$ = 60.7 can be produced from a single egg, and a maximum of four ($\bar{x}$ = 2) from a single egg of Cnidocampa flavescens, the oriental moth.

It takes 12 days for a Trichogramma generation to be completed at 25°C and 70-75 percent relative humidity. Under field conditions with fluctuating temperature and humidity, the time is longer. The Chinese have calculated that 235 day-degrees are necessary for development; this value is for degrees above 5°C since there is little or no development below this temperature. Adults emerge within 12 to 24 hours once development is completed; 80.9 percent of emergence is completed within 12 hours, and 97.2 percent within 24 hours. Females live 12 hours to 20 days ($\bar{x}$ = 4.3 days) and under artificial rearing their nutrition is supplemented with honey. Not all females are capable of producing eggs, but about 75 percent of them do. There was some confusion regarding the sex ratio, which was stated to be 90 percent females. Since most Trichogramma species are arrhenotokous, unmated females would only produce males. The probability of females mating would seem to be quite low with such a sex ratio.

In producing Trichogramma, the Chinese use unfertilized oak silk moth eggs to avoid problems with hatching first instar larvae. The number of cocoons that must be collected for release to

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control *T. dendrolimi* can be calculated by a formula developed by Yu of the institute:

$$C = 10^4 \; A_i N_i$$ where

A = area of release

N = frequency of release

C = cocoons to be collected

i = 1

Much of the information presented by Yu on *T. dendrolimi* will be published in Spanish as part of the proceedings of the VII Reunion Nacional de Control Biologica held in Veracruz, Mexico, in 1979.

At the Liaoyaun City Forest Insect and Disease Control Station in Jilin Province biological control with *T. dendrolimi* was initiated in 1970, and from 1970 to 1980 no chemical insecticides were applied. The parasites were obtained from the Jilin Provincial Forestry Research Institute. It was not clear how *Dendrolimus* populations were sampled or monitored, but the number of larvae per tree decreased from a mean of 54 (range 50-104) to 1.5 larvae, and the infested area declined from 240,000 mu to 45,000 mu during the 10-year period. With the decreasing use of chemicals, natural enemies of *Dendrolimus* have increased and probably contributed to the decline.

The Liaoyaun Station has been producing *Trichogramma* since 1970, mainly by manual labor. Oak silk moths (*Antheraea pernyi*) are reared and produce about 1.5 million eggs per year. From 60 to 70 *Trichogramma* are obtained from each *A. pernyi* egg. The technique is similar to what we saw at the agricultural station in Miyun County near Beijing. The Liaoyaun Station rears the oak silk moth adults in a solar-heated shed. The number of *Trichogramma* released per mu depends on the density of the pine moth (it was not clear if "pine moth" refers to more than one *Dendrolimus* species and includes those that feed on larch). A small, flat, cylindrical plastic container somewhat larger than a silver dollar, with small holes in it, is used for releasing *Trichogramma* (the same kind of container is used in Miyun

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County). Oak silk moth eggs, 150 in number, are placed in each container and the parasites begin emerging 12 hours after the containers are hung in trees in the forest. One per mu is used when counts of Dendrolimus larvae are two to five larvae per tree, and three cards per mu for densities of more than five larvae per tree (we were not certain if the Chinese were using cards and containers interchangeably here).

The station is experimenting with another egg parasite, Anastatus orientalis. This species is also reared from Antheraea pernyi eggs but will attack Dendrolimus eggs as well.

We visited the Jeng Yu Tan Tree Farm, which is about 80 km, and 1 hour by bus, from Changchun in Jilin Province. Of 830 hectares on the farm, about 530 have been regenerated as natural forest and 320 additional hectares are in plantations. The major pest in the plantations has been the pine moth, Dendrolimus sp. Trichogramma dendrolimi, released over the total area of the farm, has been used for control since 1965. In the past few years the population densities of Dendrolimus over 200 hectares were as follows: 1977, 0.02 larvae per tree; 1978, 0.031; 1979, 0.046; 1980, 0.022. This area had supported very high densities of pine moth in the past and the Chinese felt that Trichogramma was responsible for control.

Parasites that have been reared from Dendrolimus superans in Jilin Province are Crossocosmia zebina Walker, Rogas dendrolimi Matsumura, Telenomus dendrolimus Chu, Mesocampe grinealis Ferrire.

At the Jiangsu Provincial Forestry Research Institute, 30 km south of Nanjing in Dong Shangiao, work with Trichogramma dendrolimi for control of Dendrolimus punctatus commenced in 1973. Parasite production is limited by the availability of host eggs from Antheraea pernyi. At present, only 10,000 mu can be treated each year. Experiments have been carried out on other parasites, the most important being two species of Telenomus. Parasites reared from Dendrolimus in this province are listed on the next page.

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Rogus spectabilis
Campoplex proximus Forster
Stanaroides octocinctus Ashm.
Xanthopimpla pedator Fabr.
Coccygomimus disparis Viereck
Brachymeria obscurata Walker
Crossocosmia zebina Walker
Carcelia rasella Baranov
Euterus tabatae
Anastatus gastropachae Ashm.
Trichogramma dendrolimi
Telenomus dendrolimus
Telenomus sp.
Pachynenrov nawai Ashm.
Anastatus brevipennis
Anastatus bifasciatus Fonsed.

At the Chang Le Tree Farm in Zhejiang Province, we were told that biological control with Trichogramma dendrolimi was developed in 1972. By 1973, Beauveria bassiana was also employed, and the tree farm had established factories for both of these biological agents. Trichogramma was used on 35,000 mu, and the mean rate of parasitism of pine moth was approximately 80 percent over the first few years.

There are six steps in the Trichogramma rearing and production program at the Chang Le Tree Farm: (1) plan preparation, (2) collect Trichogramma from Dendrolimus populations in nature, (3) collect host eggs for rearing (Antheraea pernyi, Philosamia cynthia, and Dendrolimus spp.), (4) produce Trichogramma, (5) release Trichogramma, and (6) evaluate results. A total of 16-20 generations of Trichogramma can be produced per year in the laboratory. One generation takes 12 days to develop at 25°C with 80 percent relative humidity.

The host egg, from which the Trichogramma females emerge, apparently affects the vigor of the parasite. Wasps from oak silk moth eggs are healthier and live longer than those from other kinds of eggs. A single Trichogramma female can lay 200 eggs. Each oak silk moth egg is capable of producing 60-70 parasites and approximately 80 percent of the eggs exposed to the wasps are

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parasitized. It is possible to rear 10,000 Trichogramma from the eggs of one oak silk moth. One kilogram of Dendrolimus eggs will produce 4 million Trichogramma -- sufficient for release on 30 to 40 mu. All oak silk moths used for rearing at Chang Le are purchased as cocoons from Liaoning Province in northeastern China. All activities are scheduled around the pine moth, whose larvae become active in early spring. First generation pine moth eggs appear sometime after May.

Two methods of Trichogramma mass production are utilized. The first is the big room-egg card method. Cards with 2,300 oak silk moth eggs apiece are placed in a room with diffused light at one end; the cards are hung in front of the light. One thousand egg cards per day can be prepared, from which 2,300,000 parasites can be produced. The second method is to place the oak silk moth eggs in trays, thus eliminating gluing and extensive handling. Production from this latter method has more than doubled, producing 50 kilograms of parasitized eggs per day, or 5,750,000 parasites. Silk moth eggs average 115,000 per kilogram.

Trichogramma are released in stages during each generation of pine moth. There may be three to four releases 5-7 days apart. The first distribution includes 30 percent of the total parasites released; the second, 50 percent; and the third, 20 percent. This method maximizes parasite efficiency. There are six to eight release points per mu and 80,000 to 100,000 Trichogramma are released per mu depending on the density of pine moth eggs. Mean parasitization is about 80 percent. Trichogramma can be used for other pests also, such as Polychrosis cunninghamiacola, a tip tortrix, and Algedonia coclesalis, which feeds on bamboo leaves.

Workers at Chang Le discussed the limitations of both Trichogramma and Beauveria. Weather conditions, both relative humidity and temperature, can affect both agents, particularly Beauveria. Trichogramma attacks only the egg stage and cannot fly far. Attempts are being made to select the most vigorous strains of

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Trichogramma but the staff indicated there was still much remaining to be accomplished since they had only recently initiated biological control efforts. Although laboratories were spartan, they were effective in accomplishing objectives -- as at other sites we visited.

Of all the laboratories visited, this was the first one in which Trichogramma was collected from Dendrolimus eggs in the forest to initiate artificial production. It also provided the first observation that the saturnid moth, Philosamia cynthia ricina, could be used in Trichogramma rearing. It was the first facility in which we saw abdomens of the oak silk moth being stored in ice blocks about 4 x 12 inches in size. Eggs could be held for up to 1 year within the frozen abdomens without loss in production. Parasitized eggs were also held under refrigeration at 5^{o} for a month without loss.

There are 24 tree farms in Yunan County. Each produces its own Trichogramma and Beauveria. Chang Le Tree Farm treats from 5 to 8 million mu per year with Trichogramma. The delegation was amazed at the amount of oak silk moths that must be collected each year for Trichogramma rearing. In Zhejiang Province alone, 100,000 kilograms of oak silk moth cocoons are used annually. The Chinese admitted that reliance on oak silk moths is a weakness in the mass production system.

At Chang Le, a number of young workers demonstrated placement of Trichogramma release baskets within the plantation. The basket consisted of a 3-inch-wide card on which parasitized eggs were glued. This card was rolled and a string was placed through the center for attachment to a tree branch.

At the Subtropical Forest Research Institute in Fuyang County in Zhejiang Province, Trichogramma has been used as part of an integrated approach to control a pest of bamboo, Algedonia coclesalis. Rates of parasitism up to 65 percent have been attained.

At the Shashi Commune Tree Farm in Hunan Province, biological control of the pine moth was initiated in 1972 and consists of Trichogramma

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releases and application of Beauveria bassiana. Since 1972, 120,000 mu have been treated with these two biological agents.

The county forestry department has developed a system for monitoring and forecasting Dendrolimus populations. Professional monitoring people, attached to either the county or district forestry offices, report insect conditions to the forestry department. The actual forecasting techniques were not described.

Outbreaks of pine moth have declined since pesticide use was restricted and population monitoring and biocontrol were initiated. Total areas infested since 1970 are (in mu):

1970	-	310,000	1976	-	60,000
1971	-	20,000	1977	-	5,000
1972	-	29,000	1978	-	13,600
1973	-	250,000	1979	-	30,000
1974	-	16,000	1980	-	35,000
1975	-	28,000	1981	-	200
			(infested through mid-May)		

To help maintain a stable predator-parasite population, forest managers have released Dendrolimus into stands when natural populations are too low to provide adequate numbers of hosts. Also, to maintain high Trichogramma populations, they hang cards of oak silk moth and Dendrolimus eggs that have been killed by freezing. Twenty-one parasite and twenty-seven predator species of Dendrolimus have been identified, and the Chinese wish to create conditions to maintain them. They also prohibit killing of birds and have introduced an ant from Guangdong Province to help control Dendrolimus larvae.

At the Hunan Provincial Forestry Research Institute on the outskirts of Changsha, we were told that most control efforts in the province utilized biological agents. Biocontrol is annually applied on 800,000-1,500,000 mu. Of this total, 650,000 to 1,300,000 mu (85 percent) are treated with Beauveria bassiana. Sixty factories in the province produce Beauveria to

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supply the various counties for insect control, mostly against _Dendrolimus punctatus_. In addition to _Beauveria_, _Trichogramma_ egg parasites are released on 40,000 to 50,000 mu annually, and _B.t._ and some viruses are also applied in urban areas (ca. 150,000 mu per year).

Research at the institute aims at increasing the longevity of _Trichogramma_, improving field release methods, and developing artificial media for production of _Trichogramma_. Field populations of _Trichogramma_ have been maintained by placing refrigerated oak silkworm or _Dendrolimus_ eggs in the forest, a technique also used at the Shashi Commune Tree Farm. Studies on other parasitic species investigate life cycles, feeding habits, and movement within the forest. Another egg parasite, _Anastatus gastropachae_, is being reared for possible release against _Dendrolimus_, even though only one parasite develops in each host egg.

We were informed that the _Trichogramma_ rearing facilities at the institute were capable of producing 400 million _Trichogramma_ per day for release in the field. This seemed like an extraordinary output and we were not able to confirm it. The known hosts of _Trichogramma dendrolimi_ in Hunan Province are:

Dendrolimus punctatus Walker
D. kikuchii matsumura
D. tabulaeformis
D. spectabilis
D. sibiricus
Lebeda nobilis Walker
Polychrosis cunninghamiacola Liu & Pei
Actias selene Hubner
Philosamia cynthia
Phalena assimilis
Loudonta dispar (Kiriokoff)
Allobremeria plurilineata Alberti
Pantana droa Swinhae
Algedonia coclesalis

At the Xin-Hui County Forest Farm in Guangdong Province, experiments with _Trichogramma_ have been conducted since 1963. The main

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objective is some form of biological control. The researchers have used chemicals, microbial insecticides, and silvicultural methods as well, and are now moving toward an integrated management program for the pine moth. A sophisticated monitoring system is used (see Figure 2). Because of the climate, Trichogramma is less effective in this southern area than in the regions to the north. At the Gui-Feng Agricultural Farm we also heard that high rainfall made Trichogramma a poorer risk than Beauveria.

Near Guangzhou at the Bai Yun Forest Farm (Guangdong Province) we were told that the greatest loss of Dendrolimus punctatus eggs to T. dendrolimi was 29 percent but that part of this loss was also due to Anastatus gastropachae. Pupae of D. punctatus are also parasitized by a dipterous parasite, Crossocosmia zedenia, and up to 40 percent reduction of pupae has been recorded.

There are other biological control efforts in forestry in China but they are extremely small when compared with the Trichogramma efforts. At the Forestry Research Institute in Beijing we were introduced to members of a research group working on the biological control of the pine bast scale, Matsucoccus matsumurae and another research unit working on biological control of Anoplophora glabripennis, a cerambycid. We were not told details of the program for Anoplophora, but a parasitic wasp, Scleroderma sp., was being used on two other cerambycids, Saperda populnea, the small poplar borer, and Semanotus bifasciatus. The parasite on Saperda can provide up to 80 percent control.

Considerable work is being done at the Beijing Institute on predators, primarily mantids and a pentatomid, Arma chinensis Fall. The pentatomid is widely distributed and feeds on pine moth larvae as well as on a poplar caterpillar, Clostera anachoreta.

Six species of mantids are being intensively studied. They are known to prey on 40 species of pests and have a large feeding capacity. They are used against pine moth larvae, pine aphids, and a tussock moth on willow. We were told that

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populations of Dendrolimus tabulaeformis have been reduced by as much as 30 percent by mantids.

In Beijing, ladybird beetles, anthocorids, and Chrysopa spp. were being studied as biological controls for Matsucoccus matsumurae. In Zhejiang Province, 17 natural enemies have been recorded from the Hangzhou Botanical Gardens, some of which attack Matsucoccus. A native coccinelid, Ballia obscurosignata, was being reared for release against Matsucoccus scale.

At the Zhijiang Provincial Research Institute, eight researchers are concentrating on the entomology and biological control of forest insects. Emphasis is on Matsucoccus scale, which is the major pest in the Province and includes two species: Matsucoccus matsumurae and M. massoniana, the former being the more significant.

There are many natural enemies of Matsucoccus; the most important being ladybird beetles. Four species are being considered for mass rearing and release: Ballia obscurosignata, Coccinella semipunctata, Erochomus mongol, and Coelophora saucia. Ballia appears to be the most promising. According to one study, Ballia is a predator on all life stages of Matsucoccus matsumurae and occurs in at least four provinces. Since 1974, work has concentrated on biology and mass rearing of the beetle.

The life cycle of Ballia was described as having four generations each year. The shortest is from 19 to 39 days. First generation, 39 days; second, 21 days; third, 19 days; and fourth, 31 days. The adult lives under shade of the needles. Matsucoccus is the main source of food, but when the scale is small the beetle may feed on pine aphids. Adults can live for 60 days in nature. Habits of the larvae are similar to those of the adults. The fourth instar larva consumes 46 to 58 percent of all food eaten in the larval stage.

Population dynamics of the beetle were studied from 1974 to 1976, and it was ascertained that Ballia develops a stable population in pine forests. In Zhejiang it was found to be well synchronized with the pine scale. It is responsible for 48 to 76 percent predation and is more stable than other predators. In areas less

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ecologically suited, 18 to 64 percent predation was recorded. Laboratory observation indicates that second-stage larvae can consume, per day, 13 scale nymphs, 4 female adults, 265 eggs, or 28 male scale pupae. Larval predation is greater than that of adult beetles. Through all larval stages, 39-105 scale nymphs, 40-47 female scales, 39-41 scale egg clusters, and 220 male scale pupae were consumed. Both Matsucoccus and the beetle begin feeding during March. From March through May, various stages of Matsucoccus appear and feeding continues. From August to September, obvious scale nymphs appear, including egg clusters on which beetles feed. June and July being very hot, Matsucoccus scale is small and appears in a state of rest. During this period, the beetle feeds on aphids.

In the northeastern provinces, Ballia does well but has only three generations. There the beetles feed more heavily, consuming 10 to 25 scale nymphs per day, but overwintering appears to present a problem even though the beetle is capable of surviving at $0^{o}C$. Ballia has potential in the north even though it may have to be reared in the laboratory for annual release. Another coccinellid, Harmonia sp., is found in the northern provinces, it hibernates in caves. Very little effort has been directed at rearing this species.

In rearing Ballia, five to seven beetles are placed in a small jar. Larvae of male honey bees are used as a source of food. Pine needles are placed in each jar for oviposition. Approximately 400 eggs are laid by each adult female, with some females depositing as many as 1,000 eggs. In a laboratory at 25 to $27^{o}C$, adult beetles can live up to 500 days. They begin egg deposition within 15 to 20 days. Eggs are collected each day and transferred to small vials containing a diet of pig's liver, yeast, and honey. Two larvae are placed in each vial and held at 25 to $27^{o}C$. They complete development after 15 to 17 days. Food must be changed after 10 days.

Release criteria are established on the basis of the Matsucoccus population. Thirty to forty beetles will be released on each tree for every

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10 square centimeters of tree with a population of 0.5 to 1 scale.

We did not observe any of these projects but were told about them at several locations. We were also told that in Shandong Province (where we did not visit) one pair of Cyanopica cyana interposita with their young could protect one mu. The type of encouragement program and the feeding habits of the bird were not made clear.

We were also informed that at the Jilin City Forest Research Institute, about 75 forest farms were supplied with approximately 100 nesting boxes each (about 1,000 boxes total). Parus major aptatus (the great tit) used the boxes, but it is not certain if a primary cavity nester like the woodpecker, Dendrocopus major, would use a box with an entrance hole already in it. The Chinese mentioned, in passing, that this woodpecker does not feed on Dendrolimus, but it is curious that it was mentioned as part of the pine moth IPM program. Another bird, Cyanopica, (see above) was also mentioned again, but it is not certain if this is a secondary cavity nester either. We did not have an opportunity to see any nesting boxes and it was not clear how the Chinese know if any of the birds feed on Dendrolimus. To our knowledge, the effect of the feeding, if there is any, has not been quantified or published.

At the Nanjing Technological College of Forest Products we saw wooden nesting boxes prepared for birds; one type for two parids, Parus major and Aegithalos caudatus. A second type made from a hollowed log about 5.5 inches in diameter, was for woodpeckers, Dendrocopus major and D. hypertheus. The results have evidently been encouraging.

Microbial
Insecticides

Beauveria bassiana

As mentioned earlier, work with Beauveria bassiana was initiated in the 1950s but widespread use did not occur until the 1960s. It is

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now one of the most widely produced and utilized biologicals at county tree farms and communes and is most effective in central and southern China for the control of Dendrolimus. Production is based on a solid fermentation process that makes use of agricultural byproducts such as wheat bran and rice hulls. Beauveria can be over 80 percent efficacious if applied when the relative humidity is greater than 80 percent and the temperature above 25°C. It is normally applied by aircraft or backpack dusters, but occasionally by means of exploding projectiles fired from mortar-like devices into plantation areas that are otherwise difficult to reach.

There are six steps in production: (1) liquid culture for isolation of the fungus, (2) incubation, (3) solid culture of the fungus for mass production, (4) drying and pulverizing, (5) application in forests, and (6) evaluation of results. During the process, the fungus is transferred three times. The first two times are to obtain pure cultures and the last for mass production. The fungus is initially collected from diseased larvae in forested areas and incubated between 21-30°C, with 24°C being optimum. Relative humidity is maintained at 90 percent. The first two cultures are liquid and composed of potato glucose agar, sugar cane glucose, and wheat bran extracts. The third culture is solid and consists of wheat bran and rice hulls. Bamboo trays are used for solid culturing and small bottles and flasks for the liquid cultures. The liquid cultures are continuously agitated on a shaker that can hold as many as 560 flasks. After 72 hours, the medium is diluted with water to a 70:30 ratio. Three to five bottles of Beauveria are then added to one bamboo tray containing about 3-5 kilograms of dried media. The mixture is allowed to incubate for 24 days. It is then ground up to form a powder which can be stored for 2 to 3 months or immediately shipped. There appears to be no concern about the purity of the final product, which normally contains about 10 billion spores per gram. Approximately 150 kilograms of

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Beauveria can be produced each day in a small commune production facility.

Beauveria is most widely used on pine caterpillar, Dendrolimus, but it has also been applied to control other forest pests such as Algedonia coclesalis on bamboo; Ochrostigma albibasis, a notodontid on oak; and Buzura suppressaria, a geometrid pest of Aleurites fordii. Against Dendrolimus the fungus is effective on all life stages, but, there are limitations on its use. Weather conditions, both relative humidity and temperature, can affect its efficacy.

Research with different strains of Beauveria is being conducted and the Chinese are developing new techniques to measure efficacy. They have learned, for instance, that strains from south China are 20 to 40 percent more effective against Dendrolimus than strains from northern areas. Work is also being done to increase efficacy and quantities of spores by treating the fungus with CO_2 and laser beams.

Bacillus thuringiensis

Bacillus thuringiensis (B.t.) was introduced from the Soviet Union in the 1950s. The Chinese learned the methods of production and built many factories throughout China to produce B.t. Many of these factories are now closed because of erratic results obtained with B.t. One factory still in operation is located in Henan Province. Annual production at that facility is 500-600 metric tons. The production process utilizes a deep layer liquid fermentation process to make a water soluble product. When used properly, the efficacy of B.t. can achieve 80-90 percent. The Chinese consider problems of erratic results to be related to product quality, not application. The Chinese also consider B.t. to have two advantages in that it can be produced in large quantities and in many formulations. Research is now underway to improve the quality of B.t. and to develop production technology. B.t.,

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therefore, because of erratic results, is not widely utilized in forest pest suppression programs. The Chinese were very much interested in our application technology and the use of stickers, sunscreens, and other materials that could enhance the use of liquid suspensions.

Insect Viruses

Insect viruses for pest control in China are primarily in the research stage. The Chinese have succeeded in isolating granulosis, cytoplasmic, and nuclear polyhedrosis viruses from 35 species of insects (Table 2). The efficacy of some of these viruses appears to be satisfactory, but no artificial media are available to increase production. As in the United States, living insects are used.

Host larvae in the fifth or sixth instar become infected when they eat foliage with virus on the surface. Diseased larvae are later collected and a suspension of the virus is obtained. The suspension can be stored for long periods at 3-5°C and two workers can produce sufficient amounts in a month to treat 200 acres .

Virus research has shown promise for control of <u>Dendrolimus</u>. Two viruses have been isolated: a cytoplasmic polyhedrosis virus (CPV) from <u>Dendrolimus</u> and nuclear polyhedrosis virus (NPV) from a moth, <u>Lebeda nobilis</u>, a defoliator on <u>Camellia</u>. Also, NPV extracted from <u>Buzura suppressaria</u> has been successful in experiments to control the geometrid, <u>Biston marginata</u>.

Viruses listed in Table 2 were collected by the Division of Forest Entomology, the Forest Research Institute, and the Chinese Academy of Forestry. The following abbreviations are used:

CPV = cytoplasmic polyhedrosis virus
GV = granulosis virus
PV = polyhedrosis virus
NPV = nucleopolyhedrosis virus

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Table 2. Forest Insect Viruses Discovered

Scientific name (Common name)	Virus
Acidalia carticcaria (Looper)	NPV
Adoxophyes privatana W. (Smaller tea tortrix)	GV
Ampelophaga rubiginosa (Grape hornworm)	NPV
Amsacta lactinea C. (Red-costate tiger moth)	GV
Apocheima cinerarius (Elm looper)	NPV
Buzura suppressaria (Tung-oil tree geometrid)	NPV
Bhima undulosa (no common name)	NPV
Clostera anachoreta (Poplar caterpillar)	GV
Cnidocampa flavescens (Oriental moth)	NPV
Cryptothelea variegata (Giant bagworm)	NPV
Culcula panterinaria (no common name)	NPV
Dasychira abietis S. (no common name)	PV
Dasychira glaucinoptera C (no common name)	PV
Dasychira pudibunda (Pale tussock moth)	NPV
Dendrolimus punctatus (Masson-pine caterpillar)	CPV NPV
Dendrolimus punctatus tehchangensis (Tehchang-pine caterpillar)	NPV
Dendrolimus spectabilis (Pine lappet caterpillar)	CPV

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In The People's Republic of China Through 1980

Scientific name (Common name)	Virus
Dendrolimus tabulaeformis (Oil pine caterpillar)	CPV
Euproctis flave (no common name)	NPV
Euproctis pseudoconspersa (Tea tussock moth)	NPV
Euproctis similis (Mulberry tussock moth)	PV
Hyphantria cunea (Fall webworm)	NPV
Lebeda nobilis (no common name)	NPV
Leucoma candida (no common name)	NPV
Leucoma salicis (Satin moth)	NPV
Ivela ochropoda (Elm tussock moth)	PV
Lymantria dispar (Gypsy moth)	NPV CPV
Lymantria xylina (no common name)	NPV
Malacosoma neustria testacea (Lackey moth)	NPV
Parasa consocia (Green cochlid)	PV
Parasa sinica (Chinese cochlid)	NPV GV
Phalera assimilis (Yellow-tipped prominent)	NPV
Seopula subkumctaria (no common name)	PV
Thosea baibarana (no common name)	NPV
Thosea sinensis (Flattened eucleid)	NPV

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Chemical Insecticides

From the late 1950s to the present, chemical insecticides have been applied either from the ground or by air. Materials used to combat most forest pests include malathion, sumithion, dylox, and DDVP. Two techniques for application have been used: high volume (at 200 liters per hectare) and ultra-low volume. Backpack sprayers are used more frequently than aircraft to apply insecticides, but occasionally smoking is used for stands with high density crowns.

Each year about 50 percent of all infested areas recommended for control are treated with chemical insecticides. To remedy this, China would like to develop biological control on a larger scale and limit chemical insecticides to essential needs.

For many years BHC was commonly used for control of pine caterpillars (Dendrolimus spp.), and generally produced 90 percent mortality. Dylox was later substituted because of concern for worker safety. The Chinese also noted that BHC killed many natural parasites and predators of Dendrolimus. On these considerations, integrated programs were initiated in 1972.

Pheromones and Hormones

Chinese scientists are interested in pheromones for their potential use in insect surveys, in intensive studies of life history and behavior, as aids for timing pesticide application or releases of natural enemies (especially egg parasites), and possibly for direct control by mating disruption.

Pheromone research on the pine caterpillar, Dendrolimus punctatus, is in the preliminary stages. Experiments with crude pheromone extracts, however, indicate that males respond readily to baited traps. It was reported that 20 female equivalents of extract may attract 50-70

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percent of the male population within a 30 meter radius. Population estimates are made from total counts of pupae on two transects that sample about 20 trees per mu. Pheromones used in conjunction with light traps increased the catch over light traps alone by 65 percent. Researchers in Shanghai and Beijing have identified the components of the pheromone of *Dendrolimus punctatus* and have synthesized the attractant.

Workers at the Nanjing Technological College have identified three components of the pheromone of the bagworm moth, *Clania variegata*, which is a serious pest in the Nanjing area. The combination of these components is not attractive to males, however, and work is under way to identify remaining component(s) of the pheromone.

We were unable to talk with anyone directly involved with identification and synthesis of attractant compounds. Some researchers with whom we did visit, however, have used crude extracts from *Dendrolimus* spp. females to conduct life history and behavior studies.

Plant hormones and other extracts are also being studied for possible use as insect control agents. Four modes of action by hormones have been observed: (1) cessation of growth, (2) abnormal growth, (3) early maturity, and (4) sterilization. Alkaloids from a *Camptothera* sp. caused fifth and sixth instar *Dendrolimus* larvae to pupate before spinning cocoons, and 7-28 percent showed some type of physical abnormality. Also, a 75-86 percent reduction in viability of eggs was observed when treated males or females were mated with normal insects. Other experiments showed that a compound called harringtonine, extracted from a fir, *Caphalotaxis fortunei*, at 0.05 percent concentration, reduces hatch of *Dendrolimus* eggs by 92 percent.

Silvicultural Treatments

Management to prevent or minimize damage by insects and diseases has long been an objective of foresters. It is a goal that the Chinese expressed to us throughout our visit, yet we

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rarely saw evidence that much was being accomplished. To the contrary, afforestation and the need for large acreages of plantations may be creating opportunities for more extensive damage in the future. This is not a criticism. We realize that the only way to create a forest where none exists is by planting trees. Nevertheless, ideal conditions for future outbreaks are created when vast areas are planted to a single species.

The Ministry of Forestry continually stresses silvicultural control and is providing guidelines and plans for species diversification in various parts of the country. At the Forestry Research Institute in Beijing, the statement was made that silviculture is the foundation for all work at the institute.

We observed silvicultural treatments for pest management at the Liaoyaun City Forest Insect and Disease Control Station and also at the Jeng Yu Tan Forestry Tree Farm. Both of these organizations are in Jilin Province, where pines as well as larches are grown in fairly large single species plantations. Mixed plantings are more common now than in the early years, and thinning has improved the general health and growth rates of the older forests and has removed many trees of poor form. To prevent site deterioration, removal of litter is no longer permitted as it had been in the past.

Foresters managing the Chang Le Tree Farm in Zhejiang Province discussed work they were doing to reduce pure stands of pine by planting *Cunninghammia lanceolata*, *Cinnamomum camphora*, and other species. Care is now being taken to put new plantings on sites where active growth will eliminate or reduce problems which developed in earlier efforts.

In Hunan Province, at the Shashi Commune Tree Farm, we were told of recently imposed restrictions on firewood gathering to help restore balance in the forest. Forest managers there have also started on a more careful application of forest management techniques. These methods have not accomplished much to date but do indicate that more attention is being given to

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the transfer of technology by scientists from the institutes and ministry.

The forest we visited at the Shashi Commune Tree Farm had been planted to pure Pinus massoniana, but more recently had been interplanted with Camellia oleifera, Cunninghamia lanceolata, and several other species in smaller quantities. The change in stand composition from pure pine has been identified as a major factor in reduction of pine caterpillar numbers. The pines in some of these stands were in extremely poor condition -- they were about 16 years old but averaged less than 3" DBH. Most had poor form and local residents had heavily pruned them with axes leaving long branch stubs. Fuel gathering had virtually cleared away all litter and erosion was widespread. Implementation of sound management practices are changing these conditions at Shashi Tree Farm but not throughout the region. The Chinese hope that this tree farm will, in time, become a model for others.

In Guangdong Province we were impressed with the progress being made to develop a mixed forest at the Xin-Hui County Forest Farm. Some species being used are Acacia confusa, Cinnamomum camphora, Cunninghamia lanceolata, Liquidambar sp., and Eucalyptus maculata. Thinning was in progress and many stands showed the benefits where the practice had been completed in at least two steps over a 15- to 20-year-period. The southern forests grow rapidly and were some of the best managed areas that we observed. A similar observation would apply to the Bai Yun Forest Farm near Guangzhou.

Integrated Pest Management

As in the United States, there is considerable discussion in China regarding the definition of integrated pest management (IPM). The Chinese have concluded that in solving any pest problem, there is a need to work on a combination of methods; that each method, by itself, has a weakness; and that IPM can help to overcome

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these deficiencies. According to Li Yu-ming of the Ministry of Forestry, IPM theory and practice are just becoming established in China. The Chinese realize that a combination of methods _per se_ does not constitute an IPM approach. Most scientists accept the viewpoint that IPM is a concept with its roots in sound ecological knowledge of the system, sampling and monitoring of the pest, establishing economic thresholds for damage, and discovering the least disruptive methods for management.

China has moved from handpicking in the 1950s, to chemicals in the 1960s, to a combination of chemicals and biological control in the 1970s, to the present time when scientists are now trying to develop IPM strategies. With most insect pests, they are considering a variety of alternatives including chemical, biological, silvicultural, and autocidal, as discussed in prior sections.

The first location where we observed the IPM approach in practice was at the Jilin City Forest Research Institute. In the past, control efforts had consisted solely of aerial application of BHC for _Dendrolimus_. Now an ecological approach was being used which consisted of silvicultural practices to plant mixed-species forests, _Trichogramma dendrolimi_ and _Bacillus thuringiensis_ as biological controls, and an active bird management program.

The Chang Le Tree Farm in Zhejiang Province, also has programs that are evolving toward IPM. During the 1950s, the first control efforts were provided by manual labor--collecting egg masses and larvae. From the late 1950s and continuing through the 1960s, chemical insecticides were applied either from the ground or air. A total of 110,000 mu were treated by aerial application and 50,000 mu by ground. Generally, such efforts were very effective, producing 90 percent larval mortality. Because of the impact on natural enemies, integrated pest management was initiated in 1972.

The first efforts provided for population dynamics studies and development of monitoring methods. Silvicultural methods for reducing pine

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density by planting other species, such as Cunninghamia lanceolata, Cinnamomum camphora, Liquidambar, Quercus, Sassafras, and Paulownia were initiated and all species were planted in accordance with site conditions most favorable for active growth. Sanitary measures, such as removing dead branches and trees and cultivating the soil to reduce vegetative competition, were also undertaken.

In 1972, they began using Trichogramma dendrolimi; in 1973, Beauveria bassiana and, as mentioned elsewhere, they established production facilities for both of these natural enemies. Trichogramma was used on 35,000 mu with about 80 percent parasitism during the first few years. Beauveria was used on 13,000 mu with mean infection rates of 85 percent. Chemicals were applied only in emergency situations, at which time ultra low-volume ground treatments of DDVP were applied on localized infestations. Approximately 100 mu are treated in this manner each year, but in some years no application is necessary at all.

Workers at the tree farm were enthusiastic about Beauveria as a control for many defoliator pests but stressed that they understood the danger of relying on a single control tactic and the importance of adopting the IPM concept.

The ecological approach was being pursued with bamboo insects too. At the Subtropical Forest Research Institute in Zhejiang Province, we were told that chemical insecticides were used for a variety of pests but only in emergency situations. This helped to prevent excessive mortality to natural enemies.

The Shashi Commune Tree Farm in Hunan Province has also developed a sophisticated IPM approach to control pine moth. In the early 1950s, attempts to control Dendrolimus punctatus centered around manual control (collecting and destroying pupae and eggs). Chemical insecticides were used in the early 1960s but results were not satisfactory, possibly because of high mortality of natural enemies. In 1972, biological control methods were initiated; the mountainous areas were designated as a reserve

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and public access was restricted. The restricted access and, in particular, a prohibition on firewood gathering, helped to restore an ecological balance. Currently, some firewood gathering is permitted. Biological control consisted of releases of Trichogramma dendrolimi and dusting with Beauveria bassiana. Since 1972, 120,000 mu have been treated with these agents. Chemicals are still applied but their use has decreased from an average of about 100 metric tons/year prior to 1972 to about 30 tons/year. BHC, DDVP, or Dipterex, are used on hilltops and southfacing slopes where Dendrolimus populations are highest or where chronic infestations occur. Virtually all chemicals are applied from the ground as dusts, although insecticidal smokes have been used.

Pinus massoniana has been essentially eliminated from hilltops and south-facing slopes and replaced by Camellia, Cunninghamia, and native Quercus spp. The Chinese have also begun to plant loblolly pine, P. taeda, and slash pine, P. elliotii, on some of the areas where P. massoniana has been eliminated. The American pines seem to be more resistant to Dendrolimus than the native P. massoniana, although we saw some minor defoliation on slash pine at other locations. In general, conditions on the Shashi Tree Farm were better than the surrounding areas, but additional gains could probably be realized by applying silvicultural techniques, especially thinning. Thinning from below could provide badly needed fuel wood, improve stand quality, and increase tree growth.

Researchers at the Hunan Provincial Forestry Research Institute on the outskirts of Changsha are also ecologically oriented and regard biological control as the keystone in an IPM system but recognize that a single approach to insect and disease control will generally not work well. They plan to develop IPM systems which will incorporate forest management, biological agents, and judicious use of chemicals to contain or prevent outbreaks. They do not intend to attempt eradication of any pests.

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At the Xin-Hui County Forest Farm in Guangdong Province, IPM has been practiced longer than at any other units visited. These foresters have been recognized for their IPM efforts by the Ministry.

Reforestation was begun at Xin-Hui in 1949. The forest stands are essentially pure with 42.1 percent in *Pinus massoniana*, much of which was planted by direct seeding.

The region is subtropical, warm, and moist; three to four generations of pine moth can occur. During 1962-1963, a serious outbreak of *Dendrolimus punctatus* took place over 80 percent of the forest. Experiments with *Trichogramma dendrolimi* and various strains of *B.t.* have been conducted since 1963 and, more recently, IPM methods have been employed with the use of biologicals, chemicals, and silvicultural practices. Forest workers have attempted to diversify the pure stands of *P. massoniana* while using biological controls, primarily *Beauveria*. From 1963-1969, technology was developed to construct a factory capable of producing 150-200 metric tons of *Beauveria* annually with 5 billion spores per gram. The county is now self-sufficient in production of the fungus and can provide it to other counties as well. *Beauveria* is applied in four ways: (1) Release of infected living insects, (2) distribution of dead, infected insects within the forest, (3) dusting, and (4) liquid spray.

Experience thus far has shown *Beauveria* to be highly effective. In 1963, a pine moth outbreak prediction system was developed (see "Defoliators" above and Table 1) and since 1965, efforts have been made to acquire mechanical application equipment. At present, the county owns 53 pieces of equipment, including portable dust and spray applicators, blacklight traps, and field generators. Initially, the first equipment was purchased from Japan, but China now has the capability to manufacture its own equipment. The present equipment is also employed in supporting other districts within the county as well as other counties.

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An attempt has been made to practice sound forest management. The first step is thinning which includes removing weak and crooked trees to 50 percent of ground cover. Thinning also includes digging out the root systems to reduce longhorn beetle problems. Pure pine stands on hills and ridges are planted with Acacia confusa and on low, wet sites with Cinnamomum camphora, Cunninghamia lanceolata, and Liquidamber sp. In low density stands where shade is not a problem, Eucalyptus maculata can also be planted.

At present, Dendrolimus is not a serious problem and control is limited to fifth and sixth instar overwintering caterpillars (March), and to first generation caterpillars (late April or early May). Beauveria is used in each case at the rate of 1 to 2 kilograms per 50 to 100 mu. Small scale outbreaks, particularly on ornamentals, exotic plants, and recreational areas, are treated with a combination of chemicals and Beauveria.

In general, the Chinese are well aware of ecological approaches to pest management in their forests, and they are making serious efforts to incorporate the principals of IPM.

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IMPRESSIONS

The basis for this section was open and frank discussion between members of the exchange team and Li of the Ministry of Forestry two days before the team departed for the United States. During the session, team members presented their impressions of forest protection research observed over the prior 26 days. A synthesis of those impressions follows:

o At several locations we observed a single biological control tactic being used exclusively. In most instances it consisted of reliance on massrearing and release of *Trichogramma dendrolimi*.

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- We observed only a few locations where silviculture was actually providing a foundation for integrated pest management.

- We did not observe any attempts to integrate forest pathology research with forest insect problems or research.

- We perceived a lack of obvious documentation on successes in biological control or in integrated pest management although we were assured that success had been attained.

- We consider technology transfer to be excellent. We observed forest managers and workers receiving the most recent information and applying it in ongoing control programs or in integrated pest management philosophy.

- Although we observed successful Trichogramma rearing and release programs wherever we visited, we are concerned about the over-reliance on oak silkworm moth eggs for production of Trichogramma.

- We are concerned about the apparent lack of information regarding the effects of Beauveria bassiana on predators and parasites of the target species. Being a general type of fungus, Beauveria probably affects all arthropods in the same manner.

- We have observed infrequent use of silvicultural practices and intensive management of tree farms and state forests in China. If forests are planted, they should be managed.

- We have observed, in some areas, farmers continuing to collect firewood in restricted areas and in a manner which is sure to produce defects.

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- We are concerned that what we consider as two important areas of research are receiving little attention at the present time. The first of these is the larch casebearer outbreak in northeastern China, and the second is the general group of regeneration and seed and cone insects, including Dioryctria, Eucosma, and Rhyacionia.

- We feel that not enough attention is being given to insect pheromones for both detection and control, especially since they are compatible with biological control.

- We think research on mycorrhizae could be of great benefit to the afforestation and reforestation programs in China.

- We are concerned with the apparent overreliance on Trichogramma and Beauveria and feel that the present arsenal of biological control agents should be increased to include other parasite species, predators, viruses, bacteria, and protozoa.

- We think the current emphasis in forest pathology on survey is not meeting the need for control of some of China's more important forest diseases.

- We feel there is considerable need to evaluate the use of stickers, sunscreens, and other materials that could enhance the use of liquid suspensions of microbial insecticides in aerial application.

While the above observations are obviously directed at what we consider to be deficiencies in the current forest protection programs, we are unanimous in agreeing that control of China's main pest, the pine moth, is a remarkable success story for biological control in the 1970s and more recently, for integrated pest management.

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EXCHANGE OPPORTUNITIES

We feel the time is right to escalate cooperation with China. The potential cooperative ventures presented on the following pages were discussed with Li of the Ministry of Forestry. Although there was general agreement on all of them, they will probably be approached on a step-by-step basis by both governments. As noted elsewhere, we were impressed with the open discussions and willingness of our Chinese colleagues to provide information that was, in many instances, not readily available. We were also impressed with our hosts' willingness to provide samples of gypsy moth virus, *Beauveria bassiana* spores, mounted specimens of some of the major pests, and literature describing accomplishments reported in Chinese scientific journals. We feel that additional cooperation in the areas described here will provide the best opportunities for future cooperation across a broad array of topics.

Correspondence and Literature

Team members have been approached by representatives of the Ministry of Forestry with regard to developing a continuing dialogue with Chinese scientists encountered during the trip. Commitments have been made on both sides to exchange literature at the ministry and provincial level and university members have been encouraged to write directly to foresters in China desirous of cooperating. Requests for literature have been extensive and varied. For example, the Forest Protection Bureau is eager to

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exchange publications with forest insect and disease research units in the U.S. They are interested in receiving books on identification and classification of microlepidoptera, literature on borers in plantations, on artificial rearing of Trichogramma and other parasites, on artificial diets and mass-rearing of insects, on termites, bark beetles and boring insects in general, and on pheromone research, including isolation and identification of active compounds from crude extracts.

Biological Specimens

In our discussions at several locations, we specifically requested samples of B.t. and virus developed for control of Dendrolimus spp. along with other important pest species in China in exchange for similar materials developed for U.S. species. Also discussed was the possibility of exchanging parasites of the gypsy moth and the pine bast scale complex, Matsucoccus spp. The U.S. team was also requested to provide specimens of many forest diseases and forest insect pests not mentioned above. There is little doubt that this list can be expanded by either country and probably will be as needs dictate.

Scientists and Students

This subject was discussed in considerable detail since it seemed to be of great interest to both countries. Of necessity, it had to be an abstract discussion--neither country could offer commitments without candidates to evaluate. Nevertheless, a set of guidelines was approved in principle.

Correspondence to the opposite government regarding minimum qualifications required for student visas should be initiated as suitable candidate(s) are available but, in the case of the U.S., not before informal correspondence with

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an appropriate university has been initiated and a determination made that the proposed candidate can meet requirements for admission. It is further proposed that the university and the government of the PRC work out a satisfactory financial arrangement for the student. Except for the immigration requirements noted above, responsibility for exchange of students will remain with the U.S. university and the PRC government.

Exchange of university scientists can proceed in a manner similar to that described for students but, of course, the process would be greatly simplified by eliminating the student requirements. Exchange of scientists employed by the USDA Forest Service with those employed in the PRC will be negotiated on an as-needed basis and will probably be for an individual scientist who has been identified to meet a special need. It is anticipated that in most instances the period of exchange would not be more than 3-6 months. Responsibility for negotiating terms of the exchange will remain with the two governments.

Cooperative Research

This final category could include any of the prior three categories but, in addition, it is meant to reflect a sustained cooperative effort on a problem that is jointly shared by both countries. Opportunities for this type of effort were identified and discussed at several locations. Examples are as follows: 1) A joint effort to explore the possibilities of biological control of the larch casebearer in the northeastern provinces, 2) development of new strains of *B.t.*, virus, fungi, nematodes, and protozoa for control of outbreaks of major pest species of insects in both countries, 3) a joint effort to find and evaluate new parasites and predators of *Matsucoccus* spp. in both countries, and 4) combined efforts to develop, identify, synthesize, and test pheromones for a number of pest species in both countries, such as *Dioryctria* spp. and *Rhyacionia* spp.

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APPENDIX

Itinerary

Forest Pest Management in the
People's Republic of China
April 23 - May 29, 1981

Thursday, April 23

Team members depart from various locations in the United States for Tokyo, Japan.

Friday, April 24

Team members arrive in Tokyo and check into the Grand Palace Hotel in downtown Tokyo.

Saturday, April 25

Delegation meets for the first time to discuss assignments on notetaking, photography, gifts, protocol, and reports on forest pest management trip to the People's Republic of China.

Sunday, April 26

Sightseeing at various locations in and around Tokyo.

Monday, April 27 - Tokyo

0800-1400

Final packing and last minute preparation for trip to China.

1430

Leave hotel for Tokyo International Airport (Narita).

1900

Plane leaves for Beijing 1 hour late.

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Tuesday, April 28 - Beijing

0001

Arrive at Capitol Airport in Beijing, People's Republic of China. Welcome by Qiu Shou-si and Li Yu-ming of the Forest Protection Bureau and Guo De-you of the Design Institute of Forest Management (who will serve as interpreter for the first part of the trip), all from the Ministry of Forestry. Bill Davis, the agricultural attache, U.S. Embassy, was also there.

0050

Leave airport.

0125

Arrive at Friendship Hotel. McFadden discusses itinerary for our trip with Li and Guo.

0225-0300

Delegation meets to discuss itinerary for the trip.

0800-1200

Rest and organization of minor details for pest management tour.

1330-1830

Sightseeing at Forbidden City, Heavenly Temple, and Chairman Mao Square.

Wednesday, April 29 - Beijing

0830-1200

Discussion and tour of laboratories at the Forest Research Institute of the Chinese Academy of Forestry Sciences. Cui Lian-shan, Deputy Director of this Institute, conducts the meeting.

1340-1700

Continue tour of Forest Research Institute; discuss organization of the Chinese Ministry of Forestry and presentations by McFadden on organization of the USDA Forest Service and on forest protection in the United States; Knight reports on research and education in colleges and universities in the United States; and K.C. Lu on forest pathology in the United States.

Evening

Dinner at the Beijing Duck Shop, hosted by

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Qin Feng-zhu, Deputy Director, Department of Foreign Affairs, Ministry of Forestry.

Thursday, April 30 - Beijing

0745-0925

Travel to Miyun County Agricultural Plant Protection Station, 80 kilometers northeast of Beijing. Discussion and tour of Trichrogramma rearing facilities. Discussion and tour led by Lee Jian-mien, the county commissioner.

1200-1330

Lunch at the Miyun County Corporation and Cafeteria.

1330-1530

Bus tour of Miyun County and Miyun County Reservoir.

Evening

Special musical performance at the People's Great Hall, Chairman's Square celebrating May Day.

Friday, May 1 - Beijing

0800-0930

Travel to Great Wall for a day of sightseeing on China's national holiday, May Day.

1130-1205

Travel to Ming Tombs for lunch and tour.

1630

Return to Friendship Hotel for dinner.

Saturday, May 2 - Beijing

0805

Visit to Beijing Zoo.

1000

To Beijing Capital Airport for trip to Changchun in Jilin Province. Lunch at the airport cafe.

1325

Plane leaves Beijing 1 hour late due to bad weather.

1620

Arrive in Changchun after a stopover in Shenyang. Welcome by Suen Chang-jiang, Deputy Director, Silvicultural Division, Jilin Province Forestry Department and Li

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Feng-chuen of the same division. Discuss itinerary for Jilin Province and check into South Lake Hotel.

Sunday, May 3 - Changchun

0815-1155

Travel by bus 150 kilometers south of Changchun to Liaoyaun City. Welcome by Zhang Xian-zhong, Deputy Director, Liaoyaun City Forestry Department. Check into Liaoyaun City Hotel and have lunch.

1405-1440

Travel to Liaoyaun City Forest Insect and Disease Control Station. Welcome by Zhou Ju-tang, Head of the Station, and Zhao Kai-sheng and Zhao Mieng-chen. Discussion and tour of the Station Trichogramma rearing facility.

1700-1735

Return to Liaoyaun City Hotel.

1830-2045

Dinner and discussion with Jiang Chang-zi, Mayor of Liaoyaun City.

Monday, May 4 - Liaoyaun City

0735-1210

Return to South Lake Hotel in Changchun and have lunch.

1400-1445

Travel to Jilin Province Forest Research Institute. Welcome by Guo Shao-gian, Head of the Institute, and Yu En-yuh. Discussion and tour.

1750

Return to South Lake Hotel.

Tuesday, May 5 - Changchun

0740

Leave hotel and travel 80 kilometers east to Jeng Yu Tan tree farm of Changchun City. Qiou Yaing leads the tour. Returning to hotel we visit a kindergarten and department store.

1200

To hotel for lunch.

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1410
A large symposium at the hotel, attended by 50-60 individuals from six Division (Districts) of Jilin Province. Metterhouse and Dahlsten give lectures followed by discussion.
1745
Adjourn .

Wednesday, May 6 - Changchun
0740
Leave hotel for 2 hr. 50 min. bus ride to Song-Hua Lake.
1100-1530
Boat ride around Song-Hua Lake, Jilin City Forest Research Institute.
1610
Leave Jilin City and return to hotel at 1830 for dinner.

Thursday, May 7 - Changchun
0640
Leave hotel for return air trip to Beijing. Plane delayed due to bad weather (leave 0850). Plane delayed again in Shenyang where we change planes.
1335
Arrive in Beijing. To Capitol Airport Hotel. Afternoon shopping at Friendship Store and Crafts Center.

Friday, May 8 - Beijing
0950-1125
Flight to Nanjing in Jiangsu Province. Met by Li Chuan-tao, Chairman of Forestry Department and Professor of Plant Pathology; and Li, Secretary to the President.
1435
Arrive Nanjing Technological College of Forest Products for discussion.
1750
Adjourn and back to Nanjing Hotel.

Saturday, May 9 - Nanjing
0800-0915
Drive to Jiangsu Provincial Forest Research Station in Dongshangiao area. Discussion and

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tour of planted trees and laboratories.

1205-1330
Box lunch from Nanjing Hotel in Conference Room.

1330
Knight gives report on forestry education in U.S. and the spruce budworm. General discussion followed.

1605-1720
Return to hotel.

Evening
Musical concert by group from Harbin in northeastern China.

Sunday, May 10, Nanjing

Sightseeing in Nanjing. Sun Yat-sen Memorial Park and Ling-gu Pagoda in morning; boat ride in Xuan-wu Lake in afternoon.

Monday, May 11, Nanjing

1105-0820
Jiangsu Provincial Botancial Garden for discussion and tour of the garden, herbarium, and arboretum.

1330-2140
Travel by train to Hangzhou in Zhejiang Province. Discussion, while on the train, with Li of the Forestry Ministry about biological control in China's forests.

2225
Check into Hangzhou Hotel.

Tuesday, May 12 - Hangzhou

0900
Hangzhou City Botanical Garden for discussion and tour of the garden.

1155-1340
Hotel for lunch.

1415
Zhejiang Provincial Research Institute for discussion and tour of laboratories

1700-1735
Return trip to hotel.

Evening
Shanghai Chinese Ballet Opera

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<u>Wednesday, May 13 - Hangzhou</u>

0735-0855

Travel to Chang-le Tree Farm in Yuhan County, a county tree farm. Welcome by Ma, Director of the farm, and discussion by Wu Zhen-dong of forest pest control program. Tour of <u>Trichogramma</u> and <u>Beauveria</u> factory.

1205-1345

Luncheon banquet at tree farm.

1345-1440

Discussion in conference room.

1440-1600

Visit to tree farm plantation and <u>Trichogramma</u> and <u>Beauveria</u> release demonstrations.

1700-1800

Shopping in downtown Hangzhou.

1815

Return to hotel.

<u>Thursday, May 14, Hangzhou</u>

0805-0855

Travel to Subtropical Forestry Research Institute (Chinese Academy of Forestry Science) in Fuyang County for discussion and tour of laboratories.

1125-1250

Luncheon banquet at Institute.

1250-1420

Discussion of insect and disease problems of bamboo.

1420-1625

General discussion.

1625-1715

Travel to Hangzhou Hotel Exhibition Hall for shopping.

1800

Return to Hotel.

<u>Friday, May 15 - Hangzhou</u>

Sightseeing in Hangzhou. Boat tour of West Lake, Middle Lake Pavilion, Mirror Pools, Tiger Running Springs, Pagoda of Six

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Harmonies in the morning. In the afternoon, a tour of Yue-Fei Temple and Tomb, Lin Ying Si Temple, and Hangzhou City Flower Garden.

2350

Board train for 22-hour trip to Changsha in Hunan Province.

Saturday, May 16 - On train

2155

Arrive in Changsha on schedule. Welcome by Feng and Peng of Hunan Province Forestry Research Institute. Check into Xiangjiang Hotel.

Sunday, May 17 - Changsha

0825-0945

Travel to forest farm operated by a Production Brigade in Shashi Commune, Shashi District, Linyang County. Discussion and tour of forest plantation.

1300-1415

Luncheon banquet at District Building.

1415-1620

Discussion.

1620-1750

Return to hotel.

Evening

Chinese circus.

Monday, May 18 - Changsha

0805

Arrive Hunan Provincial Forestry Research Institute for discussion and tour of laboratories. All day.

1125-1140

Return to hotel for lunch.

1345-1745

Discussion and tour of plantation.

1800

Return to hotel.

Tuesday, May 19 - Changsha

Morning

Sightseeing Hunan Provincial Museum and

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Jian-Shiang Porcelain Factory in morning.

1120-1430
Lunch at Hotel.

1430-1820
Symposium at Xiangjiang Hotel with personnel from several scientific societies and colleges in Hunan Province. Presentations by Berisford, Knight, and McFadden.

Wednesday, May 20 - Changsha

0850-0920
Travel to Changsha Airport.

1010
Leave Changsha 15 minutes late.

1130
Arrive Guangzhou in Guangdong Province. Welcome by Yie Bin, Director of Administrative Office of Guangdong Provincial Forestry Bureau; Yang Jiagiu, Division Chief in Administrative Office; Lu Wen-jie, Engineer, Administrative Office; Tan Da-lin, Engineer, Forest Protection; and Gang Pei-yue, the bus driver. To lunch (except Yang) and discussion of itinerary at the airport.

1230-1605
Travel to Xin-hui County and Gui Feng Guest House in Huicheng-zhen City. Tan and Lu accompany us.

1615-1740
Discussion and details of itinerary with Chen Fu-jie, Director of Xin-hui County Forestry Bureau; Liang Rong-hua, Engineer in Forest Management and Head of Forest Machinery in County,; and Chen Jian-wang, County Foreign Affairs Bureau.

Evening
Film "The New Outlook of Xin-hui County."

Thursday, May 21, Huicheng-zhen City

0805-0905
Bus tour of Huicheng-zhen City forest farm (pouring rain keeps us on bus). Wen-Han in charge of the forest farm.

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0920-1000

Tour of Xin-hui County Beauveria factory.

1005-1020

Bus tour of Gui-Feng Agricultural Farm. Tea break at newly constructed tea house.

1040-1135

Walk from tea house to base of hill through forest on agricultural farm.

1145

Return to Guest House for lunch.

1255-1330

Discussion with Xin-hui County people at Guest House (45 min. delay for flat tire).

1415-1735

Return to Guangzhou and Zhu-dao Hotel for check-in. Yie and Ho welcome us for the Forestry Bureau of Guangdong Province.

Friday, May 22 - Guangzhou

0810-0835

Travel to Baiyun-Shan Forest Farm, 7 kilometers from Guangzhou.

0855-1215

Discussion with our hosts, Qi Hui-fang, entomologist and pathologist; and Luo Jun-guan, plant taxonomist, from the Baiyun-Shan Forest Farm at the Mountain Hotel located on the farm.

1255

Return to Zhu-dao Hotel for lunch.

1420-1610

Shopping at Guangzhou Friendship Store.

1630-1815

Discussion with Li at the hotel on our impressions of forest insect control in the People's Republic of China.

Saturday, May 23 - Guangzhou

0850-1220

Presentation by Dahlsten, Metterhouse, and Berisford to a group of 22 people from a local university and the Guangzhou Bureau of Forestry.

1220

Lunch at the Zhu-dao Hotel

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1335-1530

Continuation of discussions based on morning seminars.

1535-1605

Travel to Guangzhou People's Hospital No. 1 for a tour. Chen, the head administrator, and Yang, a registered nurse, welcome us.

1700-1730

Return to hotel.

1735-1910

Meeting with Li on possibilities for scientific exchange between the United States and the People's Republic of China.

1915

Dinner at hotel.

<u>Sunday, May 24 - Guangzhou</u>

0810-1005

Travel to Cong-hua County Experimental Microbiological Factory, 80 kilometers north of Guangzhou. Tour and discussion with Zeng, the Director, and Feng, an engineer.

1105-1135

Travel to Hot Springs Restaurant for lunch.

1310-1500

Return to hotel.

Evening

Farewell banquet at Ban-Xi Restaurant in Guangzhou, hosted by Wen Lian-guo, Deputy Director of the Guangdong Province Forestry Bureau. Yie, Tan, and Lu also attend.

<u>Monday, May 25 - Guangzhou</u>

0905-0940

Travel to Guangzhou Airport.

1035-1110

CAAC Flight 303 to Hong Kong.

1300

Check in Empress Hotel in Hong Kong and remain here finishing our report until departure on Friday, May 29, at 1215 on Pan American Flight 6 to San Francisco, except Berisford who departs on Thursday, May 28, at 1010 on Northwest Orient Flight 8 to Seattle.

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Table 3. Major Forest Insect Pests

Insect	Host	Range
Algedonia coclesalis	Phyllostachys sp.	Zhejiang, Hunan, Jiangxi and Sichuan
Ambrostoma quadri-impressum		NE area and Inner Mongolia (eastern)
Anoplophora glabripennis	Populus sp., Salix sp., Ulmus sp.	Hebai, Henan, Shandong, Shanxi, Shaanxi, Inner Mongolia, and Anhui
Apocheima cinerarius	Populus sp.	Henan, Hebai, Shanxi, Inner Mongolia, and Xinjiang
Blastophagus piniperda	Pinus sp. Larix sp.	
Ceraeris sp.	Phyllostachys sp.	Jiangxi, Fujian, Hunan and Sichuan
Coleophora laricella	Larix sp.	NE provinces
Coptotermes formosanus	Cunninghamia lanceolata Pinus massoniana	Provinces in central and south China
Dendrolimus punctatus	Pinus massoniana P. eliottii	Southern provinces
D. sibiricus	Larix sp. Pinus koraiensis P. sylvestris	NE provinces, Inner Mongolia, Hebei
D. spectabilis	Pinus tabulaeformis thunbergii	Liaoning and adjacent provinces

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In the People's Republic of China

Insect	Host	Range
Euproctis pseudo-conspersa	Camellia fordii	Southern and central provinces below Yangtze River
Ips subelongatus	Larix sp.	Heilongjiang, Jilin, Inner Mongolia
Lymantria xylina	Casuarina sp. Robinia pseudoacacea Pterocarya stenoptera	Fujian, Guangdong, Guanxi
Matsucoccus matsumurae	P. massoniana P. thunbergii	Liaoning, Shandong, Jiangsu, Zhejiang
Ocneria dispar (=Lymantria) dispar	Xylosma congestum Beticla sp. Salix, Larix Malus, Pyrus	NE area
Phycita pryeri	Pinus sp.	NE area
Polychrosis cunningham-iacola	Cunninghamia lanceolata	Southern provinces
Pyrrhalta aenescens	Ulmus pumila	Hebai, Henan, Shanxi, Shandong, and Inner Mongolia
Saperda populnea	Populus sp.	Liaoning, Hebai, Inner Mongolia, Shandong, Shanxi
Semanotus bifasciatus	Cunninghamia lanceolata	Provinces south of Yangtze River
Stilpnotia salicis	Populus sp. Salix sp.	NE area

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Table 4. Major Forest Diseases In China

Disease	Host	Range
Colletotrichum camelliae	*Camellia oleifera*	southern provinces
Cronartium ribicola	*Pinus koraiensis*	Heilongjiang and Jilin
Cylospora chrysosperma	*Populus* spp.	NE area
Fusarium oxysporum	*Pinus* spp.	All over the country
Glomerella cingulata	*Cunninghamia lanceolata*	southern provinces
Guignardia laricina	*Larix* spp.	northeast provinces
Leptosphaeria sp.	*Phyllostachys pubescens*	Zhejiang, Guanxi, and Hunan
Mycoplasma	*Paulownia* spp.	Shandong, Anhui, Henan, and Shanxi
Mycosphaerella larici-leptolepis	*Larix* spp.	NE provinces
Rhizoctonia solani	*Larix* spp.	

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Scientists and Administrators

The following men and women, forestry scientists and administrators in the PRC, met and assisted the American team on the Integrated Pest Management trip.

Beijing

<u>Forest Protection Institute (FPI)</u>

Cui Lian-shan	Deputy Director
Yuan Tzu-ling	Director Department of Forest Pathology Scientist, Professor
Huang Xiao-yun	Deputy Director Department of Forest Entomology Research Associate
Chen Chag-jie	Department of Forest Entomology Research Associate
Li Zhao-lin	Department of Forest Entomology (*Bacillus thuringiensis*) Scientist Associate
Li Tian-sheng	Department of Forest Entomology (ecology of forest insects) Assistant Research Fellow
Xu Chong-hua	Department of Forest Entomology (natural enemies) Research Associate
Zhou Shu-zhi	Department of Forest Entomology (sawfly classification) Research Associate
Yang Xin-yuan	Department of Forest Entomology (identification quarantine)

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Wang Zhi-xian	Department of Forest Entomology (virus) Assistant Research Fellow
Wang Gui-cheng	Department of Forest Entomology (virus) Research Associate
He Jie-tian	Department of Forest Entomology (virus) Research Associate
Cui Shi-ying	Department of Forest Entomology (virus) Assistant Research Fellow
Yao De-fu	Department of Forest Entomology (natural enemies) Assistant Research Fellow
Liang Cheng-jie	Department of Forest Entomology (chemical insecticides)
Wu Jian	Department of Forest Entomology Technician
Gao Lui-tong	Department of Forest Entomology Technician
Chen Mo-mei	Department of Forest Pathology Deputy Director
Jin Kai-xuan	Department of Forest Pathology Assistant Research Fellow
Shu Mei-cheng	Department of Forest Pathology Assistant Research Fellow
Liu Hui-zhen	Department of Forest Pathology Assistant Research Fellow

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<u>Research Institute of Wood Industry</u>

Zhang Hou-pei	Department of Wood Preserving Research Associate
Liu Yan-zi	Department of Wood Preserving Assistant Research Fellow
Zhuo Guan-Hua	Director Department of Wood Preserving

<u>Chinese Academy of Forestry</u>

Zhao Zhi-ou	Division of Foreign Affairs Research Associate

<u>Ministry of Forestry</u>

Li Yu-ming	Forest Protection Bureau
Qui Shou-Si	Forest Protection Bureau
Guo De-you	Design Institute of Forest Management (translator for Jilin trip)
Zheng Rui	Division of Foreign Affairs (translator for trip to Jiangsu, Zhejiang, Hunan, and Guangdong Provinces)

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Jilin Province

<u>Forestry Department of Jilin Province</u>

Suen Chang-jiang	Deputy Director Silvicultural Division
Li Feng-chuen	Engineer Silvicultural Division
Liou Zai-he	Head, Foreign Affairs
Zhao Ko	Foreign Affairs

<u>Liaouian City Forestry Department</u>

Zhang Xianz-hong	Deputy Director
Zhou Ju-tang	Head, Forest Insect and Disease Control Station
Zhao Kai-sheng	Assistant Engineer Forest Insect and Disease Control Station
Zhao Mieng-chen	Assistant Engineer Forest Insect and Disease Control Station

<u>Jing Rutan Forest Farm</u>

Oiou Yu-ying	Assistant Engineer Chongchuen City

<u>Jilin City</u>

Liou Feng-bai	Deputy Director Forestry Bureau
Fu Wan-bao	Engineer Forestry Bureau
Zeng Hai-teng	Head Forest Insect and Disease Control Station

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Tong Yeng	Deputy Head Forest Research Institute

Jiangsu Province

Nanjing Technological College of Forest Products

Li Chun-dao	Professor of Forest Pathology
Li Hung-sen	Secretary to the Vice President
Zhong Tein-yun	Vice President
Zheng Han-yie	Professor of Forest Entomology
Tang Zu-ting	Professor of Forest Entomology
Zhou Feng-chun	Professor of Bamboo Research
Zhou Xian-giuan	Professor of Forest Pathology
Tan Li-ying	Instructor in English and interpreter

Jiangsu Provincial Forestry Research Institute

Peng Qu-xian	Deputy Director
Fan Min-sheng	Research on virus production
Wang Yong-jun	Research on parasites
Qiu Zong-wei	Research on silviculture
Wang Qui-ming	Research on silviculture

Hortus Botanicus Nanjingensis

Sheng Cheng-kui	Director of the gardens and Professor of Plant Introduction
Sha Po-chi	Entomologist

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Chang Yin	Entomologist
Cheo Yung-chin	Plant Pathologist
Chin Hui-chen	Cytologist
Wang Chia-hsi	Environmental protection

Zhejiang Province

<u>Hangzhou Botanical Gardens</u>

Qian Zhu-min	Deputy Director
Yu Bo-neng	Entomologist

<u>Zhejiang Provincial Forestry Research Institute</u>

Zhou Chang-guang	President
Yang Win-hau	Party Secretary
Fany Hu-jilan	Deputy Chief Forest Protection Division
Hu Yue-ling	*Matsucoccus* research
Lian Yue-yan	*Matsucoccus* research
Yang Mu-dan	*Matsucoccus* research
Yu Siz-hong	Chief Scientific Research Management Office
Sun Yan-yi	Scientific Research Planning

<u>Chang Le Tree Farm</u>

Wu Zhen-dong	Supervisor

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Subtropical Forestry Research Institute

Cao Jing-ging	Forest insects research
Xu Tian-sen	Bamboo insects research
Tang Quan-fu	Oil-tree insects research
Zhao Jin-nian	Pine and *Larix* insects
Ge Zhen-hua	*Matsucoccus* research
Chen Ya-guang	Oil-tree insects research
Liao Tian-sen	Bamboo insects research
Weng Yue-xia	Oil-tree diseases
Hua Suo-long	Tung-oil wilt disease
Zhang Chang-ging	Oil-tree diseases
Kuai Shi-ying	Oil-tree diseases
Zhao Han-ming	Oil-tree diseases
Chen Hui-zhuan	Bamboo disease

Hunan Province

Hunan Provincial Forestry Research Institute

Peng Jian-wen	Deputy Director
He Zheng-xing	Deputy Chief Forest Protection Division
Zhou Shi-xiao	Deputy Chief Forest Protection Division
Long Feng-zhi	Forest Protection Division
Ma Wan-yan	Forest Protection Division
Tong Xin-wang	Forest Protection Division

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Fen Ju-ling	Management Officer
Chen Fo-shon	Division Chief Afforestation
Liao Fang-lin	Deputy Division Chief Afforestation
Xie Bo-chun	Information Office (translator)

<u>Forest Farm, Shashi District Liuyang County</u>

Sun Da-hang	Director Forestry Bureau
Gong You-sheng	Deputy Head Forestry Bureau
Zhou Chang-jiang	Deputy Head Forestry Bureau
Tang Jian-jing	Deputy Head Forestry Bureau
Wang Guang-giao	Deputy Director Liuyang County
Ma Wan-yan	Forest Engineer on assignment from Hunan Forest Research Institute

<u>Board Members Hunan Province Entomological Society</u>

Lei Hui-zhi	Deputy Director Associate Research Scientist Hunan Province Agricultural Academy of Science Plant Protection Institute Deputy Board Director Provincial Plant Protection Society

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Liu Yu-lin	Director Hunan Province Forestry Research Institute Engineer Deputy Board Director Provincial Forestry Society
Xia Song-yun	Entomologist Hunan Provincial Agricultural Academy of Science Plant Protection Institute
Wang Hang-guan	Associate Professor of Entomology Hunan Normal College Deputy Board Director Provincial Entomological Society Provincial Plant Protection Society
You Gui-xiang	Associate Professor Changsha Agricultural College Board Member Provincial Plant Protection Society
Gu Tai	Director Hunan Provincial Science & Technology Association
Li Guang-hua	Associate Professor Hunan Forestry College Board Member Hunan Provincial Forestry Society
Lin Gang-shi	Engineer Hunan Provincial Forestry Bureau Secretary Provincial Forestry Society

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Guangdong Province

<u>Guangdong Provincial Forestry Protection Bureau</u>

Yie-bin	Director of Administrative Offices
Yang Jia-giu	Division Chief in Administrative Office
Lu Wen-jie	Engineer, Administrative Assistant
Tan Do-lin	Forest Protection Engineer
Gong Pei-yue	Driver

<u>Xin Hui County Forest Farm</u>

Chen Fu-jie	County Forest Protection Director
Chen Jien-wang	Foreign Affairs Officer
Liana Rong-hua	Forest Engineer
Wen-han	Director, Forest Farm

<u>Gui-Feng Agricultural Farm</u>

Mok	Assistant Engineer

<u>Bai-Yun Forest Farm</u>

Qi Hui-fang	Protection Division Responsible for pathology and entomology
Luo Jun-guan	Manager (plant systematics)

<u>Conghua County Microbiological Factory</u>

Zeng Feng-jidong	Director

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